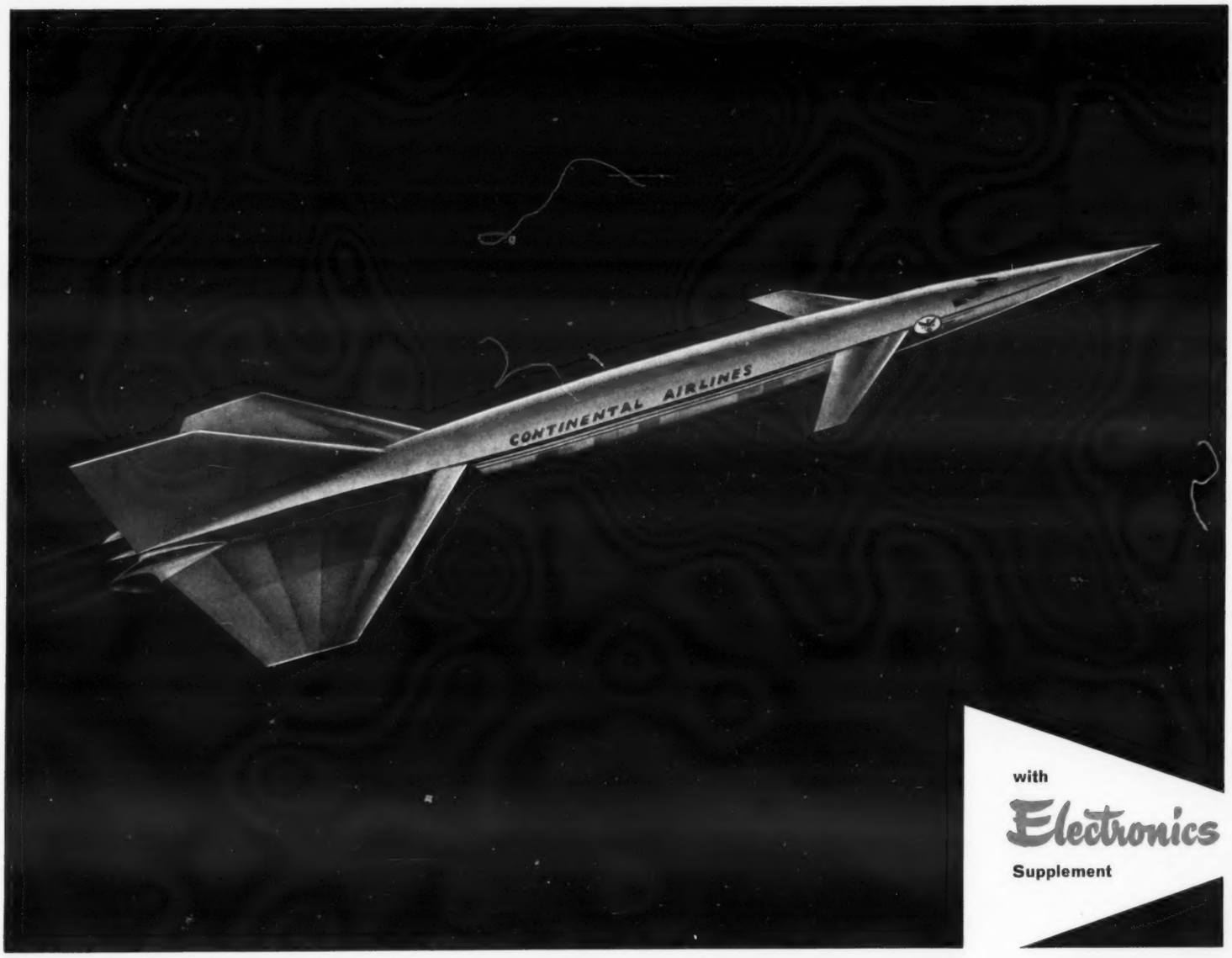
INTERAVIA

World Review of Aviation and Astronautics



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Price of this issue —
U.S.A.: $ 1.00
British Isles: 4/6
South Africa: 6 s.
Rhodesia: 6/6
Switzerland: Fr. 3.50
Germany: DM 3.50
Denmark: Cr. 6.25
France: N.F. 4.–
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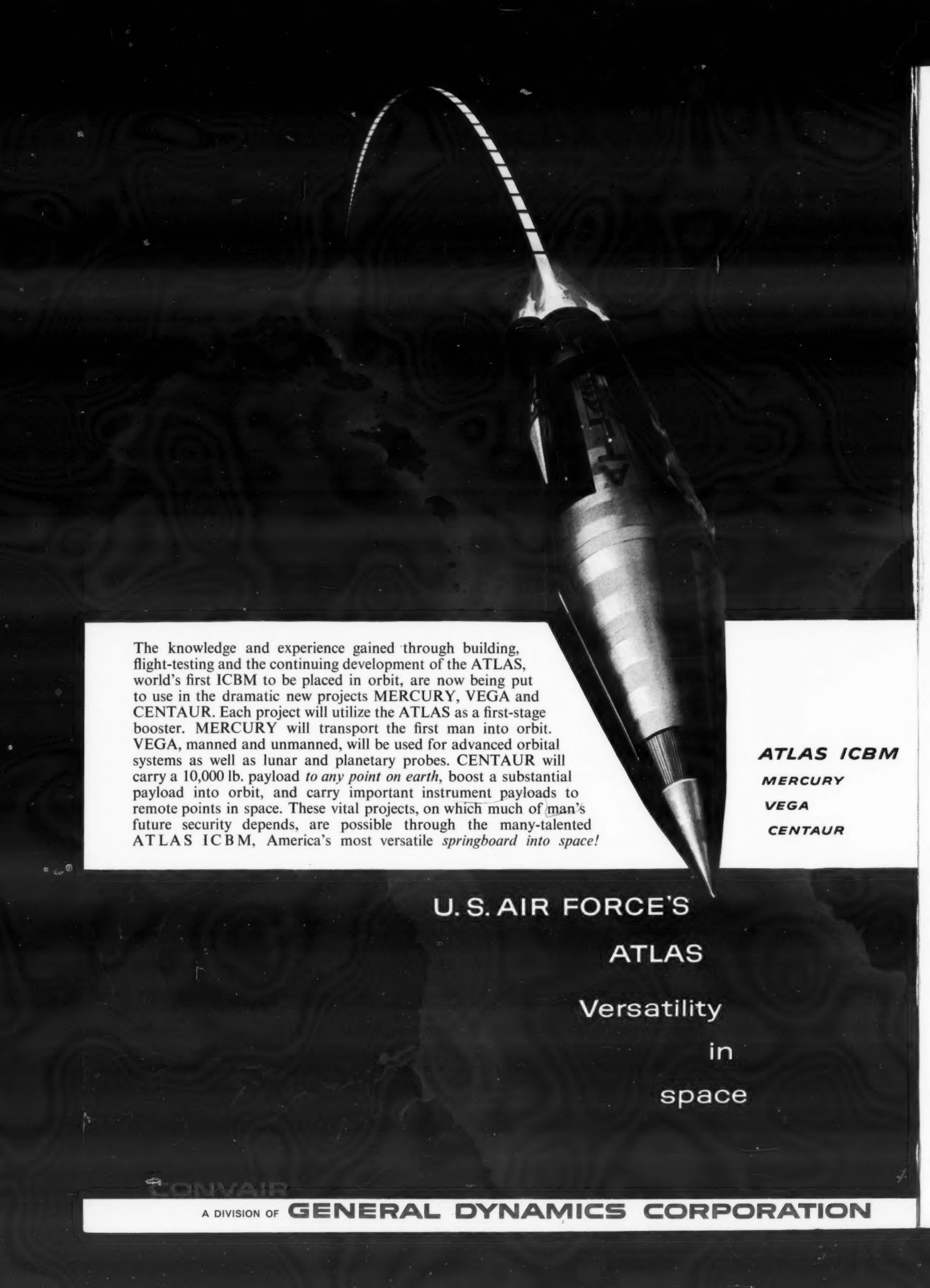
No. 1 / 1960

1960, Position and Heading

Flying Oddities



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Volume XV

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January 1960

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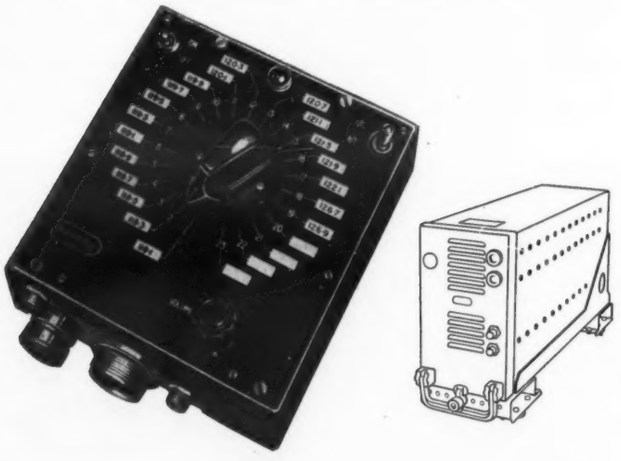

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803, National Press Bldg., Washington 4, D.C.
James C. Galloway, 6535 Wilshire Blvd., Los Angeles 48, Calif.

Distributors :

Argentina York Agency, Tacuari 178, Buenos Aires
Austria Morawa & Co., Wollzeile 11, Vienna I
Canada Wm. Dawson Subscription Service Ltd., 587 Mount Pleasant Road, Toronto 12, Ont.
Edward Company Regd., P.O. Box 98, Station Delorimier, Montreal P.Q.
Eire Basil Clancy, Cooleevin, Foxrock, Co. Dublin
Finland Akateeminen Kirjakauppa, Keskuskatu 2, Helsinki
Rautatiekirjakauppa Oy, Köjdenpunojank 2, Helsinki
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Uruguay Humanitas, Colonia 883, Montevideo
U. S. A. Eastern News Distributors, Inc., 306 West 11th Street, New York 14, N. Y.

Advertising Department, Publishing and Editorial Offices, Subscription Department :
Interavia S.A., 6, Corraterie, Geneva. Telephone: 25 42 34 (five lines). Cables and Telegrams: Interavia-Geneva. Teleprinter: 22 122. Postal Cheque Account: Geneva I 5380.

Annual Subscriptions : U.S.A. and Canada, U.S. $9.00; United Kingdom and Eire, £2.12.6; Commonwealth, £2.12.6; Switzerland, 32.— fr.; Austria, 190.— sch.; Belgium, 370.— fr.; Denmark, 55.— kr.; France, 42.— N. F. Germany, 32.—DM; Holland, 28.— fl.; Italy, 4640.— L. it.; Japan, U.S. $9.00; Latin American countries, U.S. $9.00; Norway, 57.— kr.; Spain, 450.— pts; Sweden, 40.— kr. All other countries, U.S. $9.00.
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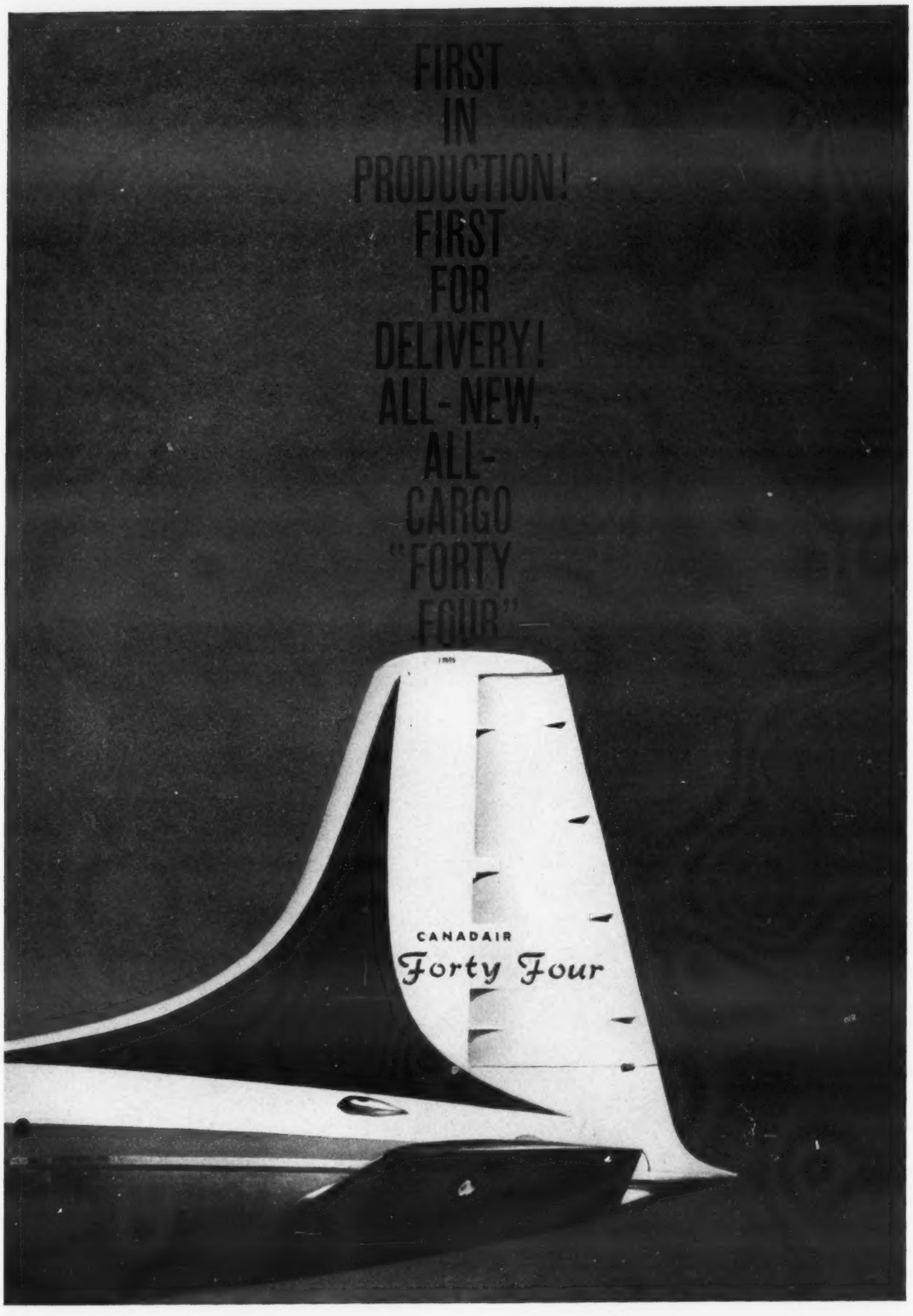
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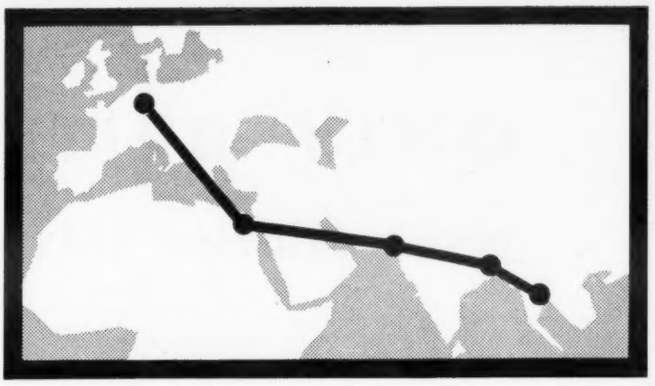

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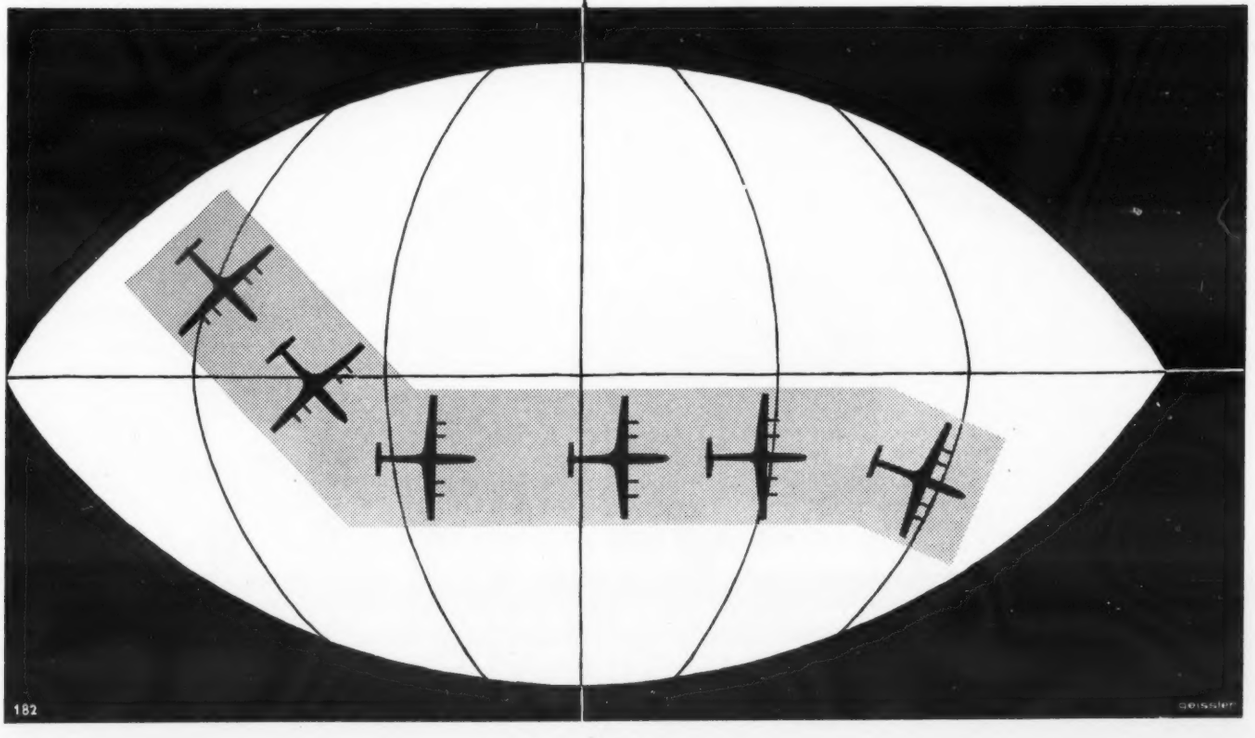

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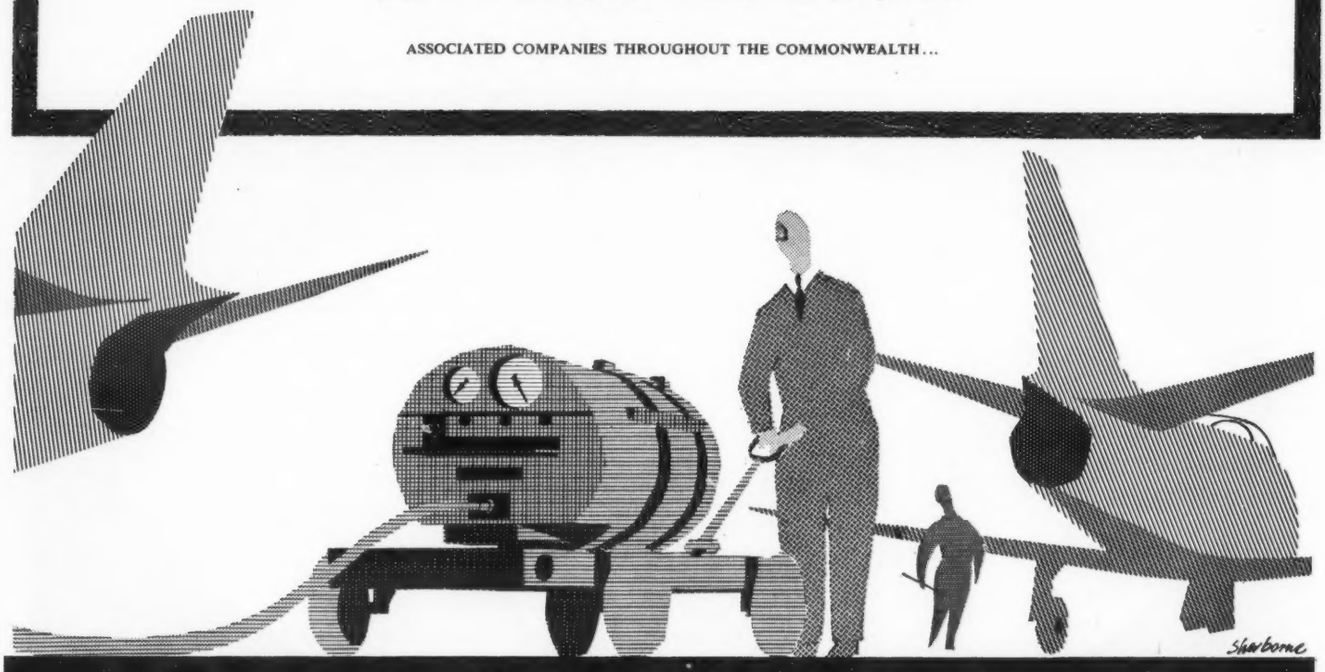

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INTERAVIA AIR LETTER reports...*

The West German Defence Ministry has announced that the Bundestag Defence Committee has approved plans to purchase an undisclosed number of Martin *Mace* surface-to-surface missiles to be equipped with atomic warheads (under American control)). The project envisages the expenditure of some DM 480 million ($114.3 million), subject to approval by the Budget Committee. The Defence Committee has also approved plans to purchase an additional 364 Lockheed F-104G *Starfighters*, to replace the Air Force's *Sabres* and F-84Fs now in service. Cost: DM 2,500 million (approximately $600 million). The new order must also first be submitted for approval by the Budget Committee; if finalized, it will bring the Federal Republic's order for the F-104 up to a total of 660 aircraft. At the present time it is not known whether the additional aircraft will be purchased direct from the United States, or will be included in the West German licence production programme now covering 200 aircraft.

●

The Martin Company plans to associate with Telefunken, Heinkel and Messerschmitt to found a concern for the manufacture of civil and military products in Germany, according to reports from the United States. Martin is said to be prepared to put up fifty percent of the capital. This report is particularly significant in the light of the above-mentioned Bundeswehr plans to purchase Martin *Mace* surface-to-surface missiles. Heinkel has also been responsible for the maintenance of Martin *Matadors* for some time past.

●

German Defence Minister Strauss and his French counterpart Pierre Guillaumat signed an agreement in Paris on December 16th, 1959, on the joint Franco-German development of a transport aircraft, known as the Transall C.160. This is designed gradually to replace the Nord 2501 *Noratlas* transport now in service with the two countries' Air Forces. A German spokesman said the agreement was a new and vitally important step towards Franco-German collaboration in the arms field. Costs will be shared equally between the two countries.

●

Britain's Short Bros. and Hawker Siddeley Aviation and Germany's Heinkel and Messerschmitt have decided to cooperate in developing a VTOL fighter. All four firms are already developing VTOL aircraft. Britain has reportedly stated she is willing to supply German firms with Rolls-Royce RB.153 engines.

●

Britain's Ministry of Aviation has announced that Britain and France are to collaborate more closely in the development of modern aircraft and guided missiles. French Minister for Air Jean Blancard has had talks to this effect with Minister of Aviation Duncan Sandys; the Ministers have agreed that increased collaboration in the field of aviation would be highly advantageous to both countries, as it would enable them to avoid duplication of effort and reduce the heavy costs involved in the development of modern aircraft and missiles. It is believed that one form of collaboration discussed may have been the standardization of aircraft types, fitting British engines of advanced design to superior quality French airframes.

●

The French aircraft industry recorded a total of 19,000 million francs ($38 million) export business in the first six months of 1959; the breakdown includes 13,800 million francs ($28 million) for aircraft, 2,700 million francs ($5.6 million) for engines, and 2,300 million ($4.6 million) for equipment. The United States headed the list of overseas customers, followed by West Germany, Israel, and Italy whose orders together accounted for 70 percent of the total. Major new orders received during the second half of the year include four *Caravelles* for Alitalia and four for Sabena, an option on a 17th *Caravelle* taken up by SAS, ten Fouga *Magisters* for Finland, and Nord-Aviation SS.10 and SS.11 anti-tank missiles in large numbers for several countries. The industry is confident that the final figure for 1959 will be several thousand million francs higher than for 1958. Over recent years there has been a steady increase in the annual figures, from 33,500 million francs in 1956 and 35,500 million in 1957 to 39,125 million in 1958. The final 1959 figure is expected to reach approximately 45,000 million francs ($90 million).

●

Allgemeine Elektricitäts-Gesellschaft reports a turnover of DM 1,377 million ($328 million) for the financial year ended September 30th, 1959, against DM 1,313 million ($312.6 million) in 1958. The Group turnover, including Telefunken GmbH and other subsidiaries, was DM 2,153 million ($512.6 million) against DM 1,955 million ($465.5 million) in the previous year. AEG production items for the aviation industry include airport power systems, approach, threshold and runway lighting systems, rotary and fixed beacons, static and mobile emergency power units, and mobile lighting systems.

●

Dornier-Werke GmbH has received a contract from the Belgian Ministry of Defence for the supply of an unspecified number of Dornier Do 27 close reconnaissance aircraft. Do 27s have also been ordered by the Swiss, Spanish and South African Air Forces.

●

Lockheed Aircraft Corporation announces the formation of a new electronics subsidiary, Lockheed Electronics Company. The goal of the expansion programme is a further diversification in electronics, a penetration of varied markets, and an increase in the civilian portion of Lockheed's overall business, states President Courtlandt Gross. The new company will include the recently acquired Stavid Engineering Inc. and the Lockheed Electronics and Avionics Division, to be renamed Stavid Division (Plainfield, N.J.) and Newport Division (Newport Beach, Calif.) respectively. David F. Sanders, former Stavid President, will be President of LEC.

Douglas Aircraft Company has handed over the first four production models of the A3D-2Q ECM and reconnaissance version of the *Skywarrior* to the U.S. Navy. The 2Q version has been specially modified for long-range reconnaissance of enemy electronic installations, with the bomb bay eliminated, and the space utilized to contain electronics equipment and stations for four operators. The basic A3D-2 bomber and the A3D-2P photo reconnaissance aircraft are already in service with the U.S. Navy; shortly to enter service is the A3D-2T version for training bomber or ECM crews.

●

Japan's Kawasaki Aircraft Co. has entered into an agreement with Vertol Aircraft for the production of Vertol 107 helicopters in Japan. The contract is to remain in force for ten years, and the royalties are to be 3.5 percent. Kawasaki is to be responsible for negotiations with the Japanese Defense Agency. Similar talks are in progress between Mitsubishi Heavy Industries and Sikorsky Aircraft for the production of the S-61 helicopter.

●

British Overseas Airways Corporation will be given permission to reduce its fares on routes within the Commonwealth, the Minister of Aviation announces. The level and timing of the cuts will be published after discussion with Commonwealth countries and the airlines likely to be affected. The announcement is regarded in London as a step towards forcing foreign carriers to accept lower fares.

●

SAS Scandinavian Airlines System will inaugurate *Caravelle* services between Copenhagen and London from April 1st, 1960. Flying time from Copenhagen to London will be cut from 2 hours 50 minutes to 1 hour 50 minutes, and from Stockholm to London from 4 hours 25 minutes to 2 hours 55 minutes. The present time of 3 hours 45 minutes from Oslo to London, via Stavanger, will be cut by one hour. In the first six months of operation, SAS's *Caravelle* fleet logged over 5,500 flying hours and carried some 70,000 passengers.

●

Sabena has placed a firm order for four SE.210 *Caravelle* jets and taken an option on a further four. The contract was signed in Brussels on December 14th, 1959, by representatives of Sabena and Sud-Aviation. The aircraft ordered are *Caravelle VIs* (two Rolls-Royce *Avon RA.29-6 Mk. 531s*). The price is $2,650,000 per aircraft, and the delivery date for all four is February 1961. The four aircraft on which Sabena has an option will be developed *Caravelle VIs* and will be ready for delivery by June 1961.

●

The East German Lufthansa plans to introduce a service between Berlin-Schönefeld and Athens, via Belgrade, using Ilyushin Il-18 turboprop airliners. The East German carrier signed an interline agreement with Olympic Airways in February last year.

●

The East German Interflug company will operate daily services between Leipzig and Vienna, Copenhagen and Stockholm during the Leipzig Spring Fair (February 28th to March 8th, 1960). Balair, KLM and Sabena will also serve Leipzig during this period, from Zurich, Amsterdam and Brussels respectively.

●

Three Chinese airlines have opened services in Kiangsi and Honan Provinces and in Inner Mongolia, according to a report from Peking. These airlines, which use the Chinese-built Antonov An-2 transport, are said to be the first to operate in central China. The routes served are Nanchang-Kanchow in Kiangsi, and Changsha-Shaoyang in

* Interavia Air Letter is a daily international news digest published in English, French ("Courrier Aérien") and German ("Luft-Post"). All rights reserved.

Honan. The service in Inner Mongolia, which is the third to be introduced in this region, will serve the cities of Tungsheng and Huhehot. The report did not state how many airlines are in operation in China, but mentioned that Peking is now linked by air with more than 70 cities in the interior and abroad.

●

Hungary and China have signed an air agreement for closer cooperation in air transport, the Hungarian MTI news agency reports. Ultimate object is to establish direct air services between the two countries.

●

The ICAO Council has unanimously agreed that the first Edward Warner Award shall go to the late Albert Plesman, founder and long-time President of KLM Royal Dutch Airlines. The award, which commemorates the late Edward P. Warner, President of the ICAO Council from 1945-1957, carries a Gold Medal, and is to be presented every second year to a personality who has made a major contribution to the development of international civil aviation.

●

Nörvenich Air Base, west of Cologne, is to be considerably developed over the next few months, and should be ready to take Lockheed F-104G fighter units from mid-1960. The main runway is to be extended to a total length of 13,125 feet. Nörvenich is currently occupied by Republic F-84F units.

●

The USAF's Air Defense Command announces that the earlier models of the Lockheed F-104 *Starfighter* are to be phased out and assigned to other duties. Four ADC units equipped with the F-104A and F-104B are to be de-activated during 1960. Reports from Washington indicate that the USAF decision was based on the F-104A/Bs' relatively short range, the fact that they are not equipped for data link computers to fit into the SAGE defence system, and their lack of all-weather capability. The later F-104C and F-104D versions are to continue in service with Tactical Air Command ; the F-104G on order for West Germany and Canada, and the F-104J for Japan have all-weather capability. Lockheed is proposing the later versions for future USAF fighter requirements.

●

The Japanese Air Self Defense Force will have a strength of approximately 28,000 men and 1,000 aircraft by the end of fiscal 1959. The aircraft include 314 F-86Fs, 52 F-86Ds, 269 T-33s, 137 T-34s, 167 T-6Gs, 35 C-46s, 8 H-19s and five other aircraft. By 1964-65 the Force is expected to have 179 F-86Fs, 100 F-86Ds, 175 F-104Js, plus 1,100 assorted trainers and transports, etc. The Air Self Defense Force comprises seven Flight Training Wings and four Air Wings. Two Air Wings are first-line and are stationed at Chitose, Hokkaido, and Komaki Air Base, near Nagaya ; the other two Air Wings at Hamamatsu, Matsushima, are advanced flying schools for the F-86F pilots, and could be called into first-line service in an emergency. The Defense Agency reportedly can muster 500 first-line jet pilots.

●

A Lockheed F-104 Starfighter piloted by Captain Joe Jordan set a new altitude record on December 14th, 1959, by climbing to 103,000 feet. The previous record was held by the Soviet Union. The *Starfighter* climbed so high that its altimeter stopped working, and ground radar had great difficulty in following its flight. The exact altitude was measured by theodolite cameras from the ground. Meanwhile the U.S. Air Force announces that Major Joseph W. Rogers set up a new speed record in a Convair F-106 *Delta Dart* on December 16th. The new mark of 1,520.9 m.p.h. replaces that set by Soviet pilot Mossolov in a Z-66. Both altitude and speed records have been submitted to the FAI for homologation.

●

Zonta International, the Service Organization of Business and Professional Women Executives, is offering grants of $2,500 to suitably qualified women wishing to study advanced aeronautics during the 1960-61 school year. The scholarships were established in 1938, in memory of Amelia Earhart, who was the first woman to fly solo from Honolulu to the United States (on January 11th, 1935). Two years later she disappeared without trace during an attempted round-the-world flight. Details of the awards can be obtained from the Amelia Earhart Scholarship Committee (Dr. Helen Pearce), 490 Oak Street, S.E., Salem, Oregon. Applications should be made before March 1st, 1960.

Workshop Briefs

LA-60 is the designation of a new single-engine multi-purpose aircraft developed by Lockheed Aircraft Corporation. The prototype was built by the Georgia Division and has recently been undergoing certification tests. Production will be carrried out in Mexico. The LA-60 is a high-wing cabin monoplane of all-metal construction designed to offer generous payload capacity with STOL capability. The fixed tricycle undercarriage is designed for rough field operation. The aircraft will be available in either a four or six seat version, convertible to cargo. Prototype powerplant is a 260 h.p. Continental IO-470-C air-cooled engine with fuel injection and constant-speed, two-blade metal propeller. Span 39 ft 4 in., weight equipped 2,024 lb (six-seat version), normal gross weight 3,531 lb, max. speed 130 knots, landing speed 69 knots, take-off distance to clear a 50-ft obstruction approx. 1,045 ft, service ceiling 16,100 ft.

●

Potez is designing and building a 16 to 24 passenger transport to be powered by four Turboméca *Astazou* propeller turbines. The aircraft, designated the Potez 840, will have a pressurized cabin. A full-size mockup has been built at the Potez plant to enable the aircraft fittings and technical equipment to be designed.

●

Following the success of the Rolls-Royce Conway engine in the Boeing 707 and Douglas DC-8, American aircraft manufacturers are now considering the use of a more powerful version of the *Conway,* and also the smaller RB. 163 engine, as alternatives for American engines in new aircraft at present under development. Boeing Airplane Company is about to offer an extra-long range version of the 707, to be designated 707-520. This will be available with either Pratt & Whitney or *Conway* RCo.42 engines. The RCo.42 has 20,000 lb thrust, and the aircraft would carry 200 passengers over stages of 5,500 miles. The company is also planning a short-to-medium haul airliner designated 727. This may have three tail-mounted engines, possibly RB.163s, and would carry 65 to 80 passengers over distances up to 1,500 miles.

Boeing, Convair and Douglas are particularly interested in an arrangement between Rolls-Royce and the Allison Division of General Motors Corp., which might lead to Allison's manufacturing Rolls-Royce engines.

●

Republic Aviation Corporation is completing work on the first operational RADFAC units (Radiating Facility for Aircraft Flight Line Testing). The unit has been developed to accelerate checks of electronic gear in the F-105 fighter-bomber, and is capable of carrying out a complete electronic check of the aircraft in 60 seconds. The equipment is housed in a trailer and can be as far as two miles away and still function effectively. The trailer is air-transportable and utilizes self-contained power supplies. All aircraft within RADFAC's operational radius can query it and check out their own systems, either one at a time or simultaneously. On a signal from the pilot, using a remote-control unit, RADFAC checks the aircraft's electronic systems and pinpoints any malfunction. Although developed for the F-105, the new system can be adapted to other types of aircraft and electronic equipment. The first unit will be in use in January ; four additional units are on order.

●

Australia's Government Aircraft Factories have received orders for a total of 214 *Jindivik* target drones, including 154 for the Weapons Research Establishment (Salisbury and Woomera, South Australia), 50 for use at proving grounds in Britain and 10 for the Royal Swedish Air Force. Australian Minister of Supply A. S. Hume has forecast orders for an additional 40 *Jindiviks* for the U.K. and an unspecified number of the higher-powered *Jindivik Mk.2B* for Sweden. Fairey Aviation is the agent for sales of the Jindivik in Europe, but contrary to earlier reports is not planning to produce the drone under licence.

Meanwhile, an improved version of the *Malkara* anti-tank missile, developed by the Australian Department of Supply, is under test. This will have " increased range and versatility in handling." The Minister of Supply has said that the Government Aircraft Factories will soon begin delivery of the *Malkara* weapons on order for the British Army ; the size of the order has not yet been disclosed, but has been officially described as substantial.

●

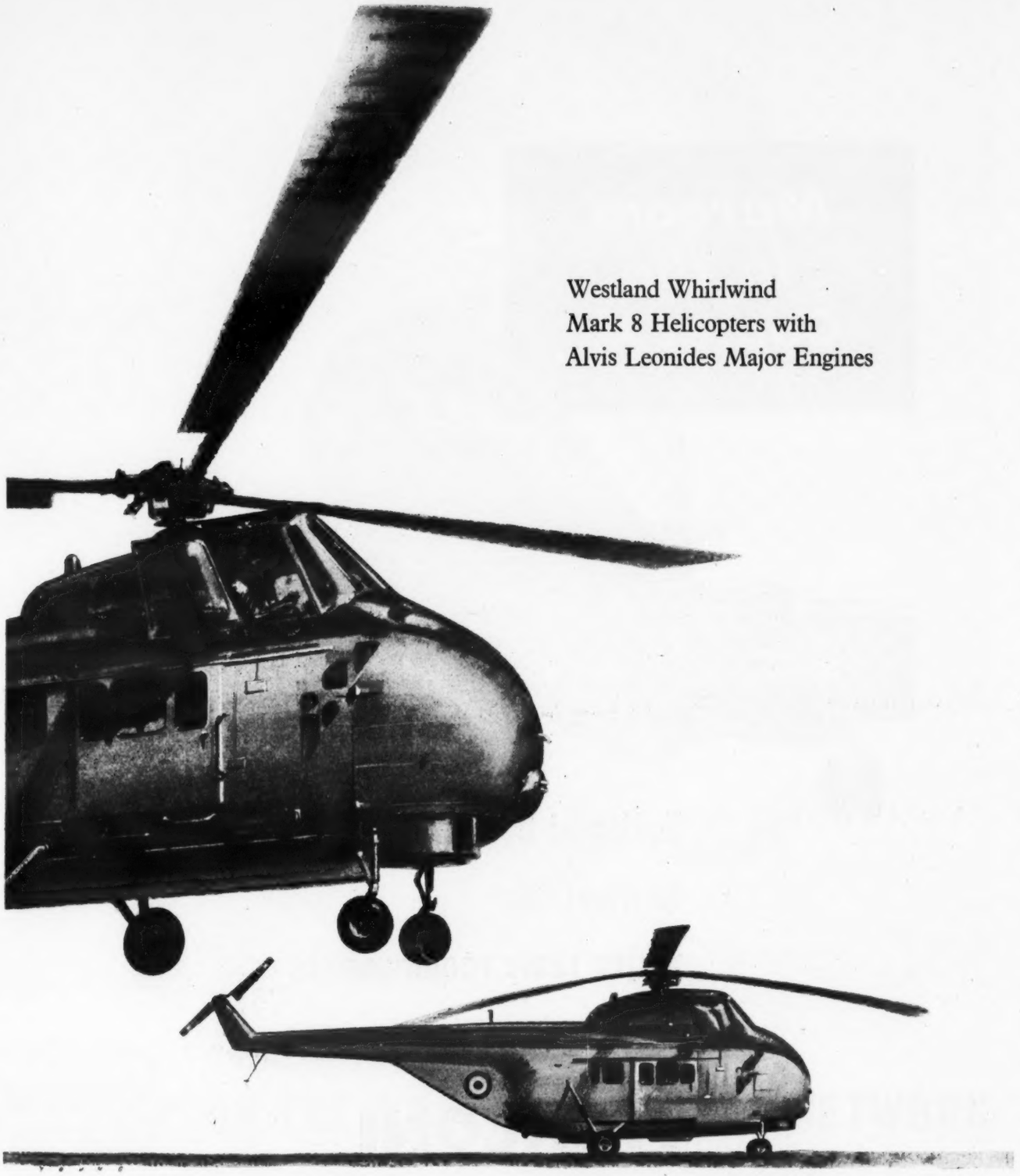
The Allison Division of General Motors Corporation has received an Air Force contract for development of a 7.5-ft twin-blade propeller for use with the 250 h.p. Allison T63 turbine engine. Designated the Model 272, this propeller will have variable governing, normal and emergency feathering, aluminium hub and blades, ice control and a completely enclosed plastic spinner. Under development since mid-1958, the Allison T63 is designed for light single-engine and twin-engine aircraft. A turbo-shaft version has been selected for the modified Bell HUL-1 helicopter.

●

Telefunken has developed a new pocket-size D/F equipment, with an accuracy of better than ± 1°. It can be used, for example, for reception of communications, weather reports, warnings or sea rescue SOS's, to determine position and bearing and for homing onto known navigation beacons.

Correction

The Editors are thoroughly ashamed at having overlooked a serious typographical error which crept into the review of Paul Wilkinson's " Aircraft Engines of the World," in the November issue. They apologise abjectly for having thus increased the price of this book from $15 to £15, and sincerely hope the oversight will not have dissuaded readers from buying this excellent reference work.



Westland Whirlwind
Mark 8 Helicopters with
Alvis Leonides Major Engines

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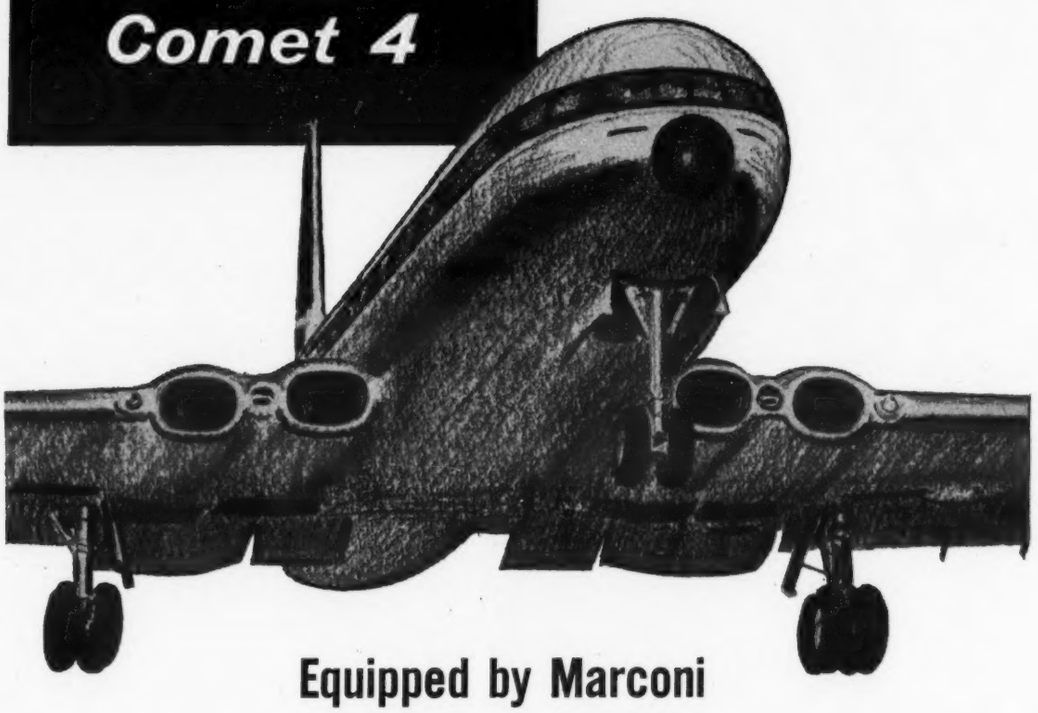
Marconi in the Comet 4



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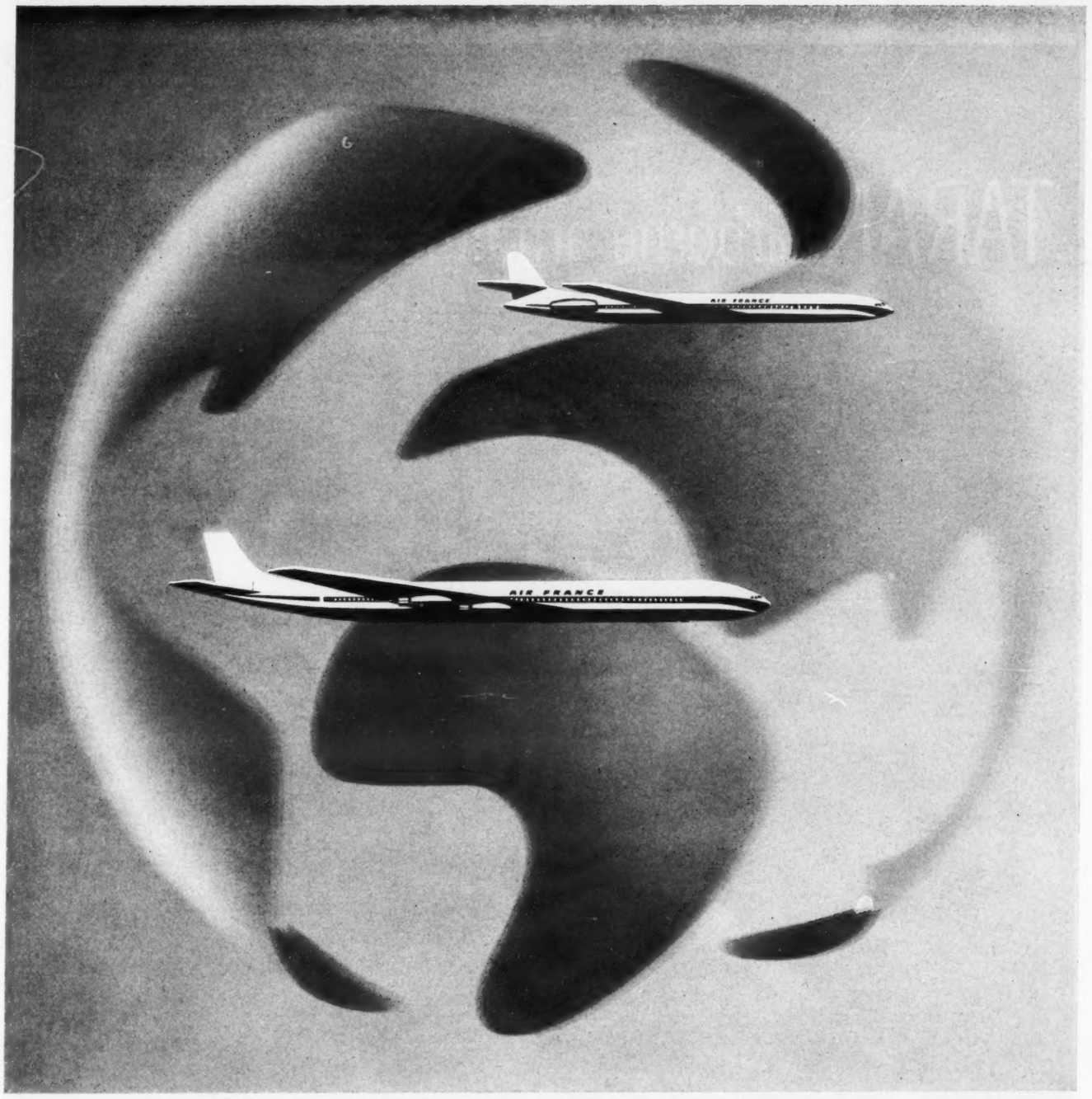

Caravelle
BOEING 707
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At 500 m.p.h., in the limpid blue of high altitudes, the CARAVELLE glides silently along like a sailplane, recalling the latter's clean, functional and thoroughbred lines. The Caravelle is the quietest aircraft in the world, where passengers can relax in peaceful surroundings.
The Caravelle's jets bear the signature Rolls-Royce.
At 625 m.p.h. the spacious BOEING 707 INTERCONTINENTAL is the first four-engined jet capable of making the crossing from Paris to New York non-stop. Air France has laid out the giant cabin to give you a unique degree of comfort. In the first class, for instance, there are new, extra-roomy seats (2 abreast), with wide arms, reclining backs, foot-rests and couchettes. Meals are prepared in the best traditions of French cuisine. Finally, a revolutionary innovation aboard an aircraft: a full-size bar.

The CARAVELLE *is now in service on most of Air France's Middle East and European network :* PARIS-BEIRUT, PARIS-ROME-ATHENS-ISTANBUL, PARIS - MILAN - ATHENS - ISTANBUL, PARIS - LONDON, LONDON - NICE, NICE - ROME, LISBON - PARIS, PARIS - TEL AVIV, PARIS - ALGIERS, PARIS - WARSAW - MOSCOW.

The BOEING 707 *serves Air France's intercontinental routes :* EUROPE - SOUTH AMERICA, EUROPE - CANADA, EUROPE - NEW YORK, EUROPE - CALIFORNIA, EUROPE - AFRICA, EUROPE - JAPAN (over the Pole).

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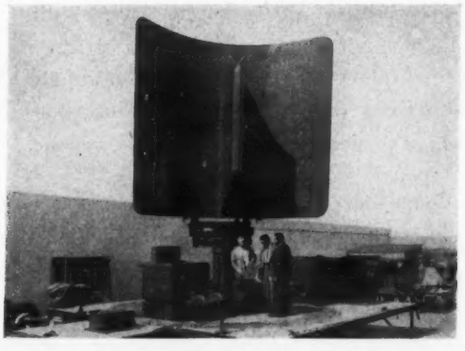
TARAN is a lightweight, compact system easily adaptable to a variety of aircraft. TARAN is extremely flexible...accommodating guns, rockets, radar and infra-red guided missiles and bombs.

TARAN is but one of a long list of important electronics systems and devices developed and manufactured by Hughes Aircraft Company. These activities cover virtually every electronic field: air-to-air guided missiles, advanced airborne control systems, space ferries, ground control-radar surveillance systems, microwave communications systems and others. Hughes commercial products include: diodes, transistors, rectifiers, traveling wave tubes and direct-view storage tubes. These products, in use throughout the free world, are tangible evidence of the reliability and benefits they give to their users.



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FALCON AIR-TO-AIR GUIDED MISSILES *have been an important factor in establishing Hughes as a leader in advanced airborne electronics. Falcon missiles are equipped with either infra-red or radar guidance systems.*

For further information please write to Hughes International, a division of Hughes Aircraft Company, Culver City, California, U.S.A.

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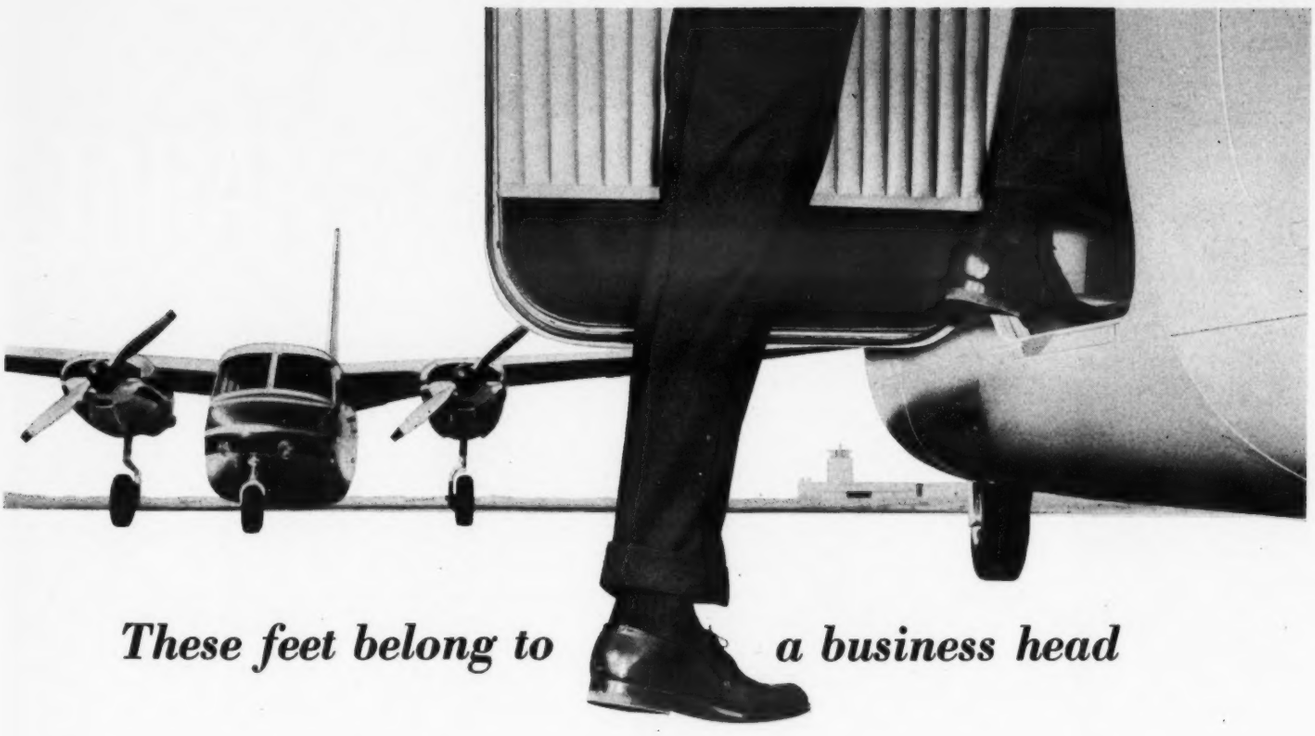

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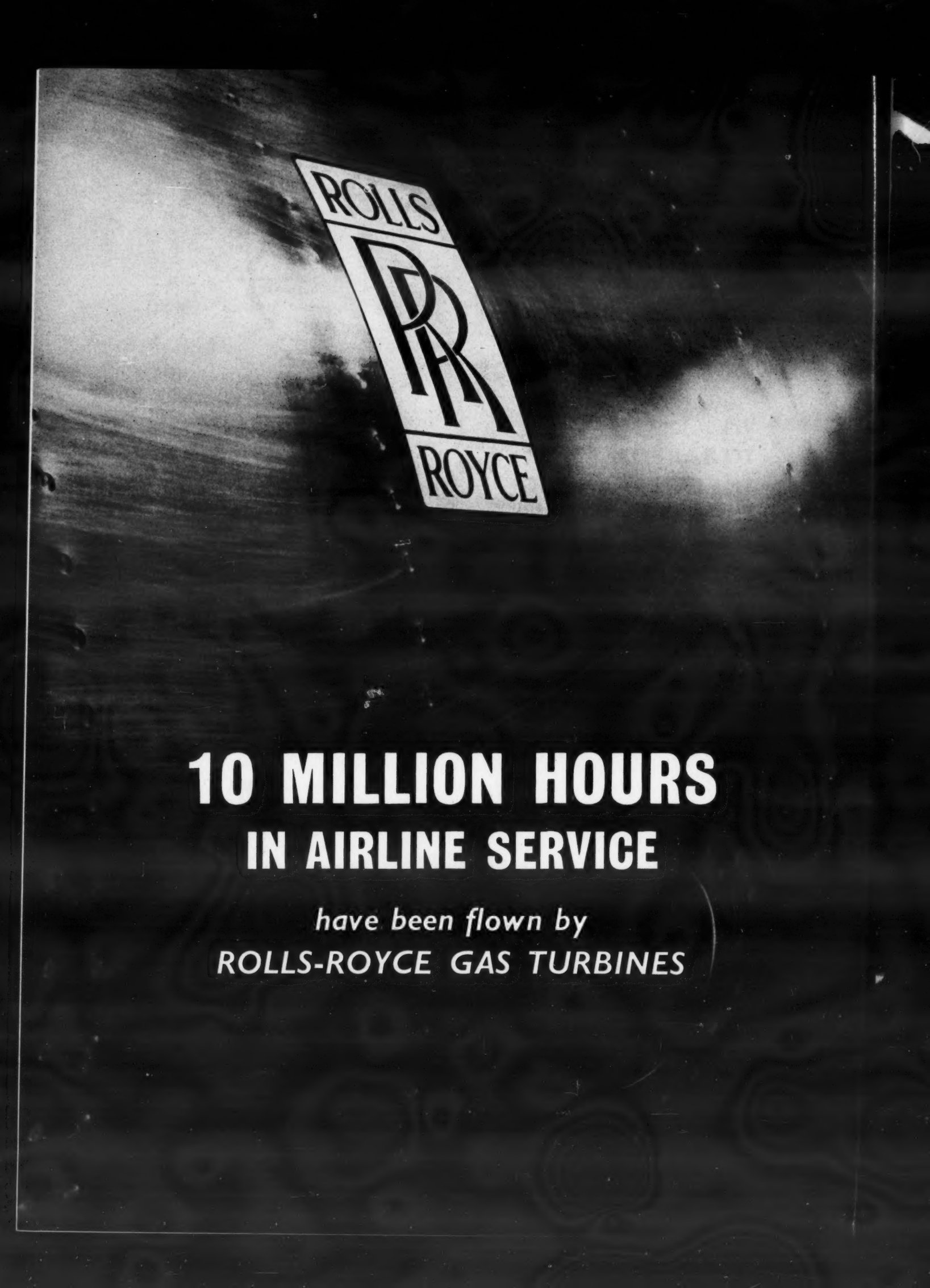

10 MILLION HOURS
IN AIRLINE SERVICE

have been flown by
ROLLS-ROYCE GAS TURBINES

VISIT
A
F

No Milk and Honey for El Al

When the sixteen ministers of the new Israeli Cabinet sit down to deliberate on the urgent questions before them, Transport Minister Yitzhak Ben-Ahron will submit one particularly urgent file entitled "Future of the national flag carrier, El Al."

At the end of 1956 Louis Pincus resigned as Managing Director of El Al, stating that the Israeli Government was not prepared to advance the funds needed to reorganize and expand the company. His office was taken over by 42-year-old *Brigadier General Aluf Ephraim Ben-Arzi*, a man in the prime of life, who as former Quartermaster General to the Israeli Army and adviser to the Ministry of Economics on industrial planning had all the organizational qualities required. Obviously, however, inadequate funds cannot be entirely replaced by good organizing gifts.

Like other airlines, El Al has in no way been neglected by the jet aircraft manufacturers. For months past representatives from Douglas, Boeing, Convair, de Havilland and Sud-Aviation have been relaying each other at the company's head offices in Maza Street, Tel Aviv. In another direction Managing Director Ben-Arzi and his colleagues have been talking with some of the Air Union member airlines on the possibility of arriving at some form of technical or fleet cooperation to tide El Al over until it gets its own jets. How far these feelers will be successful remains to be seen.

★

Actually this is not the first time that El Al has had to face similar problems. Ever since its foundation on November 15th, 1948, the company has suffered from the soft currency of the young Israeli State. Having grown out of an air transport organization to meet logistic requirements during the Palestine war, El Al was so to speak a somewhat under-nourished war child. No fairy godmothers brought it rich gifts : an extremely modest supply of dollars and sterling, a shell-torn airport building in Lydda, some 50 mechanics, a handful of foreign pilots, a few surplus transports from U.S. military stocks and half a dozen commercial employees . . . so it began.

Services began in July 1949, with four Douglas C-54 *Skymasters* (DC-4s) which flew to Rome and Paris, and later to London, Vienna and Istanbul. These aircraft were subsequently replaced by Curtiss *Commandos*, which in turn gave way to four Lockheed 049 *Constellations*. The latter continue to serve El Al faithfully on all routes with the exception of the North Atlantic, for which four Bristol *Britannia 313s* were purchased at the end of 1957, and the South African route to Johannesburg, which is operated with a DC-6B chartered from Sabena.

When El Al took delivery of the first of its four *Britannias* on November 22nd, 1957, everything seemed to be going well. Admittedly the four turboprop machines, complete with spares, finally cost a total of roughly 40,000,000 Israeli pounds (1 I.£ = $0.56 at the official rate). This was no small sum for a company depending on State support, but the El Al planners hoped that their fleet problems were now solved for the next eight years. This hope proved to be unfounded. Delivery of the *Britannias* was delayed for twelve months, which meant that they came into service too late—or the jets appeared on the world air transport scene too early. Whichever formula one adopts, the fact remains that unless El Al acquires jet aircraft by 1962 it will be in a critical competitive position.

Turning to financial results, we find that the last published figures date back to March 31st, 1958. Up to April 1st, 1957 total losses had amounted to I.£ 12,406,000 (roughly $7,000,000), to which figure another I.£ 1,038,000 ($580,000) were added during the 1957-58 business year. Figures for 1958-59 will not be produced until the Government's budget is submitted to Parliament. But it has already been estimated that total losses to March 31st, 1959 will be found to amount to more than I.£ 16 million.

As already stated, the Israeli State as main shareholder would be responsible for setting the company to rights and advancing the funds needed to buy jets. But in view of El Al's capital situation, it is not altogether surprising that the authorities are showing a certain reserve in this direction.

Long-term debts (including loans for *Britannias*)	I.£ 27,308,000
Current debts	I.£ 21,663,000
Real estate and other fixed assets	I.£ 29,480,000
Liquid assets	I.£ 8,495,000

★

Bearing in mind El Al's operating losses and debts and the general budget situation, many people are asking whether Israel really needs a national flag airline and, if so, whether this company should engage in trans-Atlantic services or merely confine itself to the European area.

El Al's supporters counter these "defeatist" arguments by insisting it is a well-proven fact that Atlantic services are the most profitable of all air transport operations. Above all, however, they claim that El Al has not only particular national commitments, but also special chances which no other airline can match.

- The Israeli nation owes its growth to mass immigration. Whereas total population at the time the State was created in 1948 included no more than 650,000 Israelis, by 1952 another 650,000 had joined them from 40 different countries, and today the population has reached the figure of nearly one and half million. A substantial number of these immigrants came in by air.

- Israel is still virtually in a state of war with all its Arab neighbours. Twice during the twelve-year history of the Israeli State, it has been found that foreign airlines have suspended their services to the country as soon as the international situation became tense.

- Because of the large number of Jews living in most Western countries, and because of the great attraction which Palestine exercises on tourists from throughout the world, El Al feels justified in counting on an exceptionally large increase in passenger volume. According to a recently-published study by the Israeli Ministry of Transport, some 75,000 foreign tourists were carried in 1958, and nearly 100,000 in 1959 ; by 1965 this number is expected to have grown to 163,000. Add to these the trips made by Israeli citizens, and we get an estimated figure of 400,000 return jouneys for 1965, some 280,000 of them by air.

However, El Al must share this lucrative tourist business with ten foreign airlines, and so far has not succeeded in securing more than 50 percent of the total : 1956—42 percent, 1957—44 percent, 1958—45 percent, 1959 an estimated 50 percent. The management is urging restrictions in favour of the national carrier. But the Israeli Government has refused to countenance any discrimination against foreign airlines, placing political goodwill above purely commercial interests.

Whether in financial questions, fleet problems or the need to raise traffic volume, the Israeli airline will require plenty of backbone if it is to survive the next few years in a healthy state and to continue on its upward trend of development.

Operating statistics
(1959 figures are estimates)

	1959	1958	1957	1952
Revenue passengers (excluding special flights)	87,500	66,191	43,600	21,904
Revenue passenger / miles (in 000)	—	160,241	90,866	60,984
Revenue freight (kg)	1,750,000	999,248	662,515	768,003
Mail (kg)	—	207,659	191,012	—

INTERNATIONAL MEETINGS AND CONFERENCES

Jan. 7th-10th : Fourth International Symposium on Radioactive Isotopes. Bad Gastein, Austria.

Jan. 8th-9th : First Meeting of the International Committee on Space Research (COSPAR) under its new charter. Nice, France.

Jan. 11th-13th : Sixth National Symposium on Reliability and Quality Control in Electronics. Washington, D.C.

Jan. 11th-15th : Society of Automotive Engineers Annual Meeting, including aviation sessions. Detroit, Mich.

Jan. 11th-15th : COSPAR 1st International Space Science Symposium. Nice, France.

Jan. 12th : Royal Aeronautical Society, 94th Anniversary Lunch. London.

Jan. 12th-13th : ATA Air Express Committee. New York.

Jan. 12th-16th : Sixteenth Annual Technical Conference of Plastics Engineers. Chicago, Ill.

Jan. 14th-16th : Agricultural Aircraft Association, 10th Annual Convention. Palm Springs, Calif.

Jan. 14th-20th : American Astronautical Society, Sixth Annual Meeting. New York.

Jan. 19th : Royal Aeronautical Society. "Some Aerodynamic Problems of Engine Installation," by Dr. J. Seddon. London.

Jan. 19th: IATA Traffic Conference 1, Agency Committee, 29th Meeting. New York.

Jan. 19th : IATA Composite Agency Committee. New York.

Jan. 19th-21st : American Meteorological Society, 40th Anniversary Meeting and Annual Business Meeting. Boston, Mass.

Jan. 19th-Mar. 22nd : "The Exploration of Space," course of lectures for non-specialists organized by London University's Department of Extra-Mural Studies. London.

Jan. 20th-21st : Airport Operators Council, Board of Directors Meeting. Washington, D.C.

Jan. 25th-28th : Eleventh Annual Plant Maintenance and Engineering Conference. Philadelphia, Pa.

Jan. 25th-28th : 28th IAS Annual Meeting. New York.

Jan. 26th-Feb. 20th : ICAO, 3rd African-Indian Ocean Regional Air Navigation Meeting. Rome.

Jan. 28th-29th : ARS Solid Propellants Conference. Princeton, N.J.

Feb. 1st-4th : Instrument Society of America, Winter Conference and Exhibit. Houston, Tex.

Feb. 3rd-5th : 1960 Winter Convention on Military Electronics. Los Angeles, Calif.

Feb. 10th-12th : Seventh Annual Solid-State Circuits Conference. Philadelphia, Pa.

Feb. 16th-18th : First National Symposium on Nondestructive Testing of Aircraft and Missile Components. San Antonio, Tex.

Feb. 22nd-26th : Engineering Materials and Design Exhibition and Conference. London.

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From the World's Capitals

Paris

If there were such a thing as a "thermometer of optimism" for the French aircraft industry, its mercury at the moment would be barely above freezing point. Admittedly everybody knew from the start that the budget just passed by the Assembly would be an austerity budget, but it was still hoped that it would provide some funds for new developments. Alas, there is no figure mentioned for a successor to the *Griffon*—which would have enabled Nord-Aviation's work on the combined ramjet-turbojet powerplant to be continued, a logical development for future supersonic airliners—nor for a possible successor to the Potez-Fouga *Magister* trainer, or finally for the "twin-turboprop overseas aircraft." Fortunately the Breguet 1150 and 941 and the Max Holste *Super Broussard* will probably be ordered in quantity, to join the present Dassault *Etendard IV, Mirage III, Mirage IV,* Breguet *Alizé* and Potez-Fouga *Magister*. Then there is also the Transall project . . .

This medium-weight cargo aircraft (C-160) is all that remains of the Franco-German cooperation on which so many hopes were founded. Germany's selection of the F-104 in preference to the *Mirage III,* and her development of a medium-stage twin-jet transport (rival to the *Caravelle*) and a twin-turboprop aircraft (rival to the *Super Broussard*) have practically destroyed all hopes of a European industry.

. . . Meanwhile, France is seeking closer contacts with Britain, just as Britain—who is feeling American pressure in Europe—is in turn seeking closer contacts with France. French manufacturers point out, not without some bitterness, that Britain has always sold them a large number of engines and equipment, but has never bought anything from France. Here, too, there is no great feeling of optimism.

The same applies to the missile field. The United States Government has forbidden American manufacturers to provide SEREB with any technical assistance, and the talks which this company has been having with Boeing and Lockheed have come to a dead end. Will SEREB come to a preliminary agreement with other European countries—and Chairman Cristofini is the former Secretary General of Western European Union—in order to qualify for American aid ? Or will France go ahead on her own and build an intermediate-range missile with her own resources—a missile which would be more costly and take longer to develop ?

★

The only real reason for satisfaction is the success of the *Caravelle.* Now that Sabena's order has been received, it looks as if the twin-jet French airliner—which has proved very popular among passengers—may also be the subject of orders from across the Atlantic, orders which may be quite substantial . . .

But at the moment this is pure speculation, while the items on the debit side are only too positive . . . and the thermometer shows no sign of rising !

London

For more than a year now it has been no secret that the British Government has been bringing pressure to bear on the aircraft industry to "rationalize," the ultimate object being to arrive at two efficient airframe groups with powerful financial backing and two similar engine groups. Yet the speed with which steps have been taken towards this goal has still come as something of a surprise.

The Hawker Siddeley Group, which has already recently taken over Folland Aircraft and is in the process of absorbing Blackburn and General Aircraft, has now issued a joint statement with de Havilland Holding Co. that the two companies are talking merger. Hawker Siddeley has offered de Havilland shareholders the following deal : (a) exchange of the 8,800,000 de Havilland ordinary shares (par £1) for Hawker Siddeley ordinary shares (par £1) at the rate of one for one ; (b) three $5^1/_2$ % preference shares plus 20 shillings in cash for every four $5^1/_4$ % de Havilland preference shares (total value £1,200,000). As at the time of the announcement de Havilland shares were selling on the London Stock Exchange for 21 shillings, while Hawker Siddeley shares were quoted at 30 shillings, the offer must be considered as a generous one. This view appears to have been shared by the stock market, since within 24 hours de Havilland shares had climbed from 21 to 26 shillings and closed at 26s. $10^1/_2$d.

The financial strength of the powerful new block is beyond question—combined assets of the two concerns stand at almost £90 million—as is also its industrial efficiency.

Critics of the merger policy object that an increase in the size of a group is not necessarily synonymous with an increase in its overall efficiency, and certain circles would have preferred a freer kind of cooperation between independent companies. For example, de Havilland, Fairey and Hunting had already formed a consortium known as Airco to develop and produce the DH.121, while English Electric and Vickers have joined forces to develop the TSR.2 strike aircraft. What the future of the Airco project will be remains to be seen.

The only major concerns still outside any form of combination are Rolls-Royce and Handley-Page.

Beirut

In an exclusive interview with Interavia, Sheikh Najib Alamuddin, Chairman of Middle East Airways, said that "a United Arab airline is an ultimate reality for both national and economic reasons." He added that close commercial and technical cooperation would be the first step, with standardization of equipment among the main Arab airlines to follow. Given political stability in the area, the Middle East will rise in importance in the 1960s, both as a gateway to the Far East and as a purchaser of aviation equipment. A good barometer is MEA itself, where in the period January to October 1959 total passengers carried went up 44 percent over the previous year—to 119,902—and revenue rose from just over £2 ½ million in 1958 to £3,351,000 in 1959. Of particular significance is MEA's 75 percent increase in freight on regular services, from 736 tons in January to October 1958 to 1,288 tons in the same period in 1959.

With an estimated average traffic growth of 15 percent per annum through the next five to seven years, and 34 *Viscounts* and 130 obsolescent transports to be replaced, the Middle East is likely to cause a considerable increase in "brochure bag" travelling from both sides of the Atlantic.

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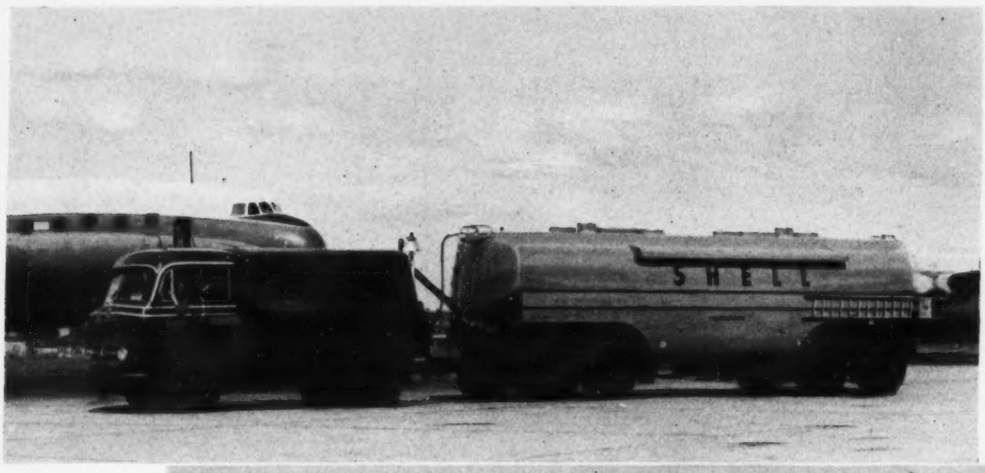

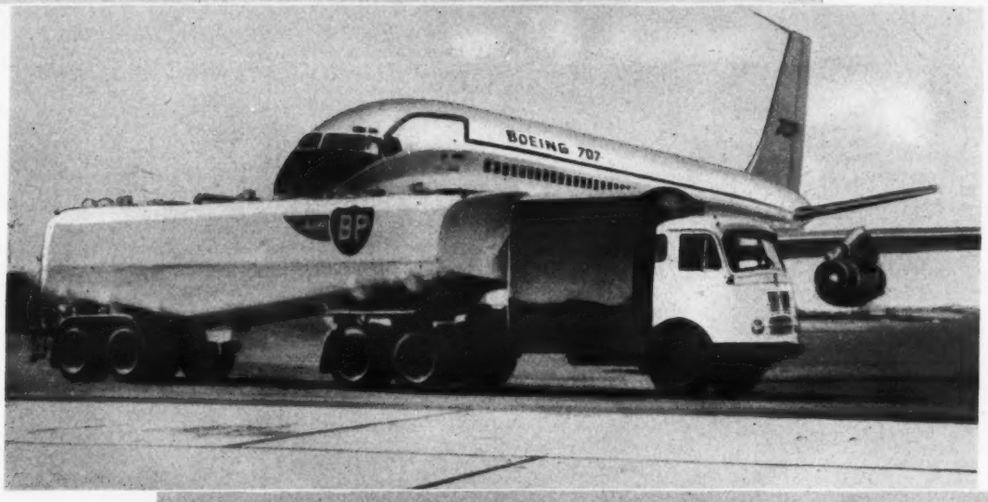

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1960: the triumph of jet transport

4 "Caravelle"

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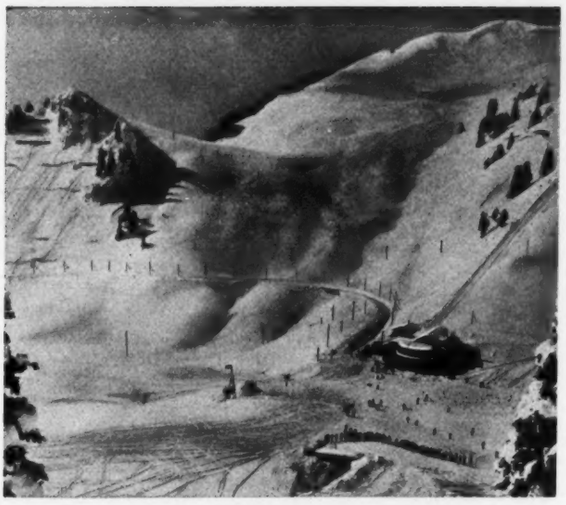

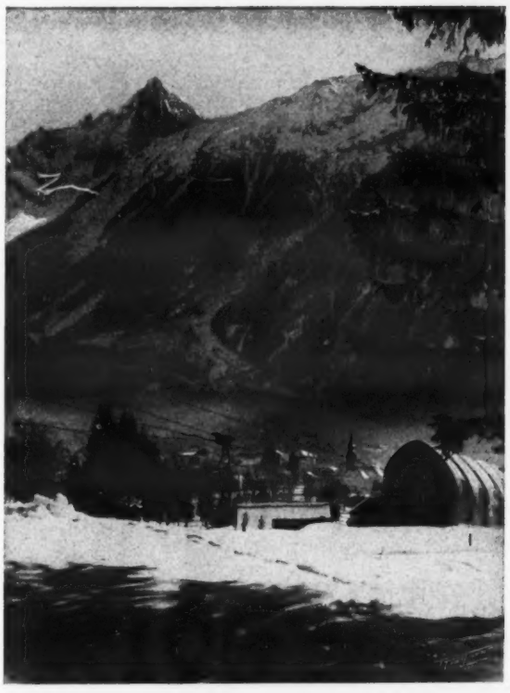

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...the retread that gives up to 50% more landings for jetliners

Cross-section of Jet-Tred showing fabric reinforcement that equalizes modulus between cord body and tread for reduced heat build up and a cooler running, longer wearing tire. Reinforcement improves tread retention by distributing stresses, checks formation of standing waves by restricting casing and resists cutting and puncturing.

Two important Thompson innovations in retread construction . . . fabric reinforcement and greater tread depth . . . combine to improve tire safety, protect casings for longer service and increase number of landings per tread by up to 50%. Fabric reinforcement acts as an insulator to reduce heat build up and permit tire to run cooler and resist abrasion. It keeps cuts from growing and penetrating casing. With extra tread depth of Thompson's patented slotted design that provides greater tire surface contact with runways, Reinforced Jet-Tred* stays on the plane longer, reduces costly downtime and schedule interruption, protects expensive casings for additional retreading.

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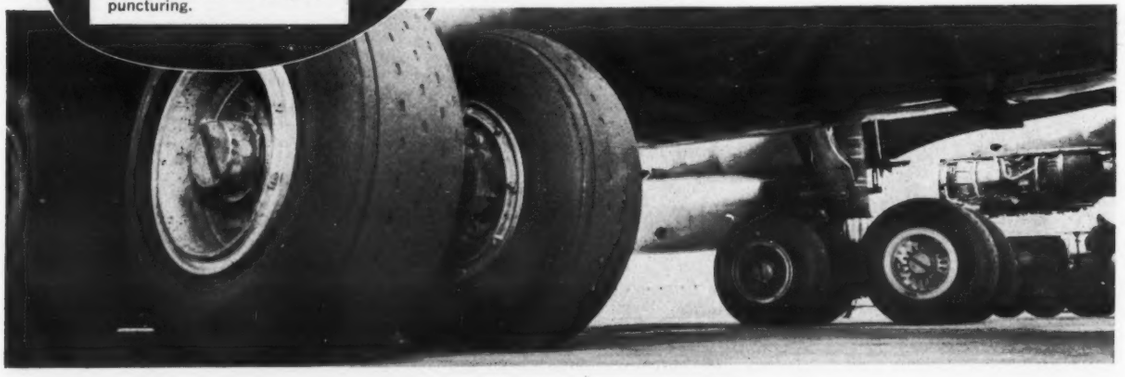

THE C 450 "COLEOPTER"

With its revolutionary design, this experimental aircraft, for **vertical take-off and landing,** opens up new prospects for aviation in the following fields :

propulsion,
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With its ability to operate without runways or costly ground handling equipment, the **C-450 COLEOPTER,** whose technology can be used on remote-controlled aircraft or missiles of all kinds as well as on piloted aircraft, constitutes a vital step forwards in the history of aviation.

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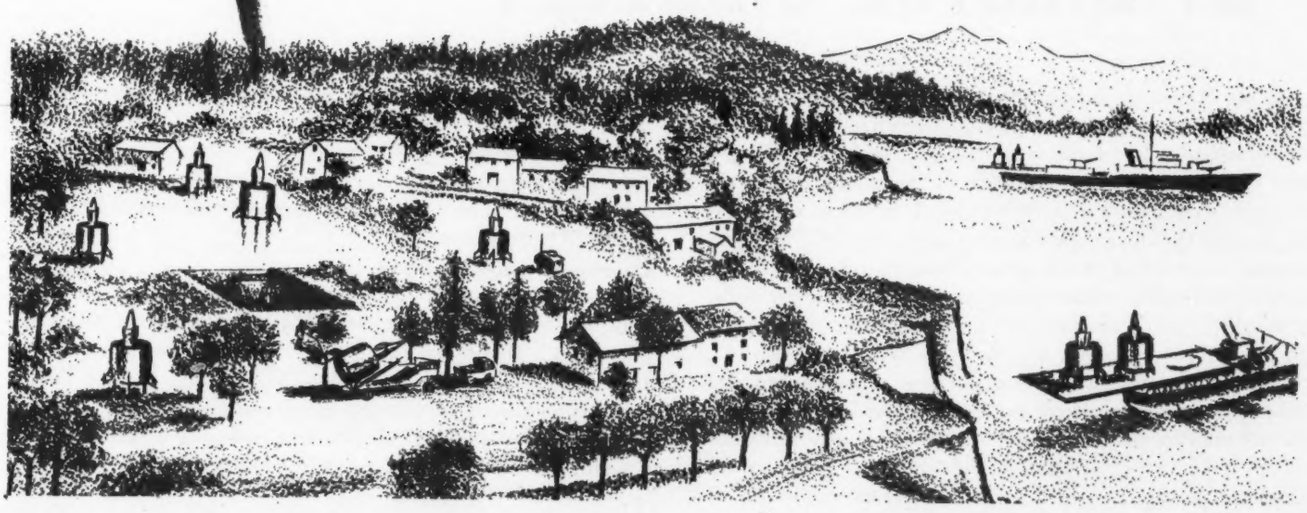
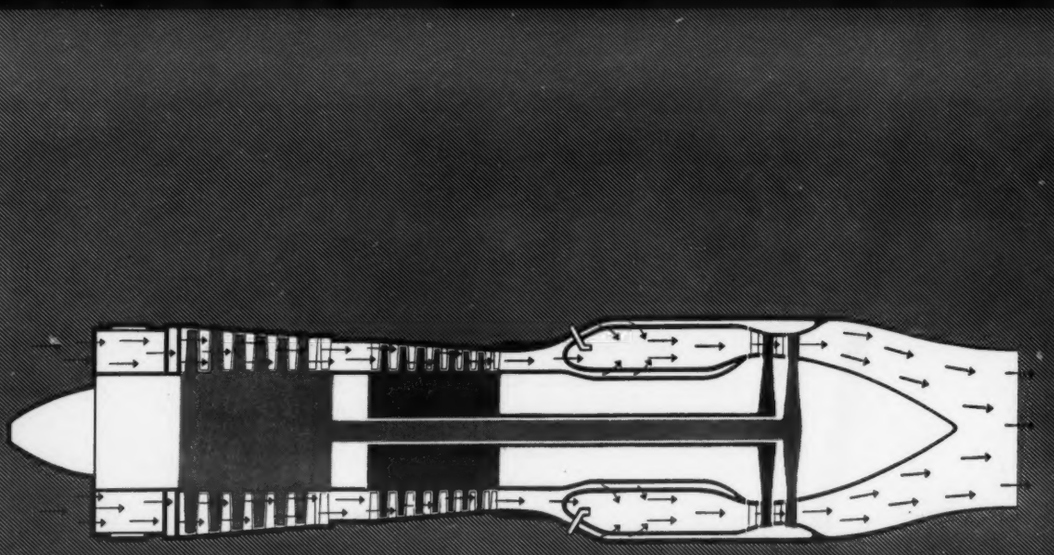


Olympus turbojet – high power, low fuel consumption, superb handling qualities, great development potential . . .



...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Olympus. The Olympus is one of the most powerful and efficient high-thrust turbojets in service anywhere and therefore most of the performance details are security restricted. It can be said, however, that the Olympus possesses outstanding handling qualities. In a slam acceleration to full power from ground idling it considerably betters the official requirement. It also has one of the lowest specific fuel consumptions and the highest thrust/weight ratio of any type-tested aero-engine in its class.

The Olympus owes its excellent all-round performance to the two-spool compressor system, pioneered by Bristol Siddeley and since adopted by the leading aero-engine producers in Britain and the USA. Proof of Olympus reliability is given by the fact that it already has the longest overhaul life of any British fighter or bomber powerplant. And the series has been proved to have enormous development potential. The first production version delivered 11,000-lb thrust dry, while the current engine reaches 17,000-lb thrust dry (24,000 lb with fully variable reheat). Even more advanced Olympus versions are rated at 33,000 lb with reheat.

Olympus applications

The Bristol Siddeley Olympus is ideally suited to operation at transonic and supersonic speeds. The Mark 201 gives the Avro Vulcan B 2 V-bomber an all-round performance unsurpassed by any other aircraft of its type. The Olympus has also been selected for the very advanced Vickers/English Electric TSR-2, the RAF's new tactical support/reconnaissance aircraft. Other Olympus versions are under active consideration for the next generation of civil airliners—the supersonic transports.

BRISTOL SIDDELEY ENGINES LIMITED

Technology, Servant and Master

The year just beginning will first and foremost be marked by the "thaw" in East-West relations. The world desperately needs to believe in this *détente*, whether it is a real one or not. Then, the more specific domain of aviation will be influenced by the United States' economic policy, by the latest military "new look" and by the pace of technological development in both weapons and civil transports.

However, the new coexistence—and the good relations which may perhaps grow out of it—can be based only on positions of strength. Both Washington and Moscow know that, for many years to come, neither of the two Powers can be allowed to gain any technological or military lead which would make the use of force a paying proposition. Washington and Moscow also know—particularly Washington—that if the *status quo* were not founded on mutual "terror," the stronger would crush, or at any rate subjugate, the weaker. This means that the scientific and technical race will continue as relentlessly as before, to ensure that the balance of power—and consequently the peace dictated by it—remains perfectly stable.

The new U.S. defence estimates bear out this idea. Although the total funds requested are the same as for the current fiscal year, their purchasing power has fallen because of the constant increase in the cost of weapons. But in accepting the austerity budget, President Eisenhower probably feels that he will be able to insist on the abandonment of out-dated lines of development and to reduce the many cases of duplication still to be found in the list of weapons under development or in construction in the United States.

But although the defence budget remains more or less untouched, the same cannot be said of the foreign aid programme. There is a profound difference of opinion between the foreign aid advocates and the Bureau of the Budget on the total to be devoted to this programme. The Advisory Committee on Voluntary Foreign Aid, under William H. Draper, former U.S. Special Representative in Europe, is asking for an increase in the funds allocated for the United States' allies, while the Bureau of the Budget and the remainder of the Administration are demanding cuts in expenditure—for the good reason that the country's balance of payments deficit in 1959 amounted to some 4 billion dollars. The U.S. Government and private citizens spend more outside the United States than foreign countries spend inside the States. One way of staunching the flow of dollars would be to cut foreign aid payments.

In the face of this shortage of funds, a new foreign aid policy is envisaged. The United States' allies are divided into two categories: on the one hand the richer countries who are economically strong enough to meet their own military needs; on the other the so-called poor countries who still require financial and material aid. The first group will continue to receive research and development contracts, but will no longer be supplied with equipment of all kinds; the second will still be able to receive American equipment or equipment paid for with American money. In Western Europe, such countries as Britain, Federal Germany and France obviously fall into the first category, while—in view of the cost of modern weapons—nations such as Norway, Greece or Turkey must be listed in the second. The new policy means that a greater production effort will be demanded of Europe's industrial nations. This would be an ideal opportunity to revive Western European Union and turn it into a truly productive organization. More particularly, it should at last be possible to arrive at an agreement between Britain, France and Germany (involving later Italy and the Benelux countries). But here several conflicting trends come to light.

One is the movement on foot to unite the production efforts of Britain and France, for example by fitting France's first-rank airframes with Britain's no less excellent engines and perhaps British electronics. Admittedly agreement is not easy to reach, but the crisis facing both industries is severe, and American competition is becoming increasingly dangerous.

This American competition is, in fact, the second important factor in the present situation. Here the key figure is West Germany. After the breakdown of her efforts to co-operate with France she has turned to the United States. By purchasing manufacturing licences for high-class equipment—airframes, powerplant, electronics—and by modifying this equipment to meet European needs, she has at once put herself in the lead and gone far towards opening for herself tomorrow's world markets.

Thirdly, budget limitations have led the Pentagon to consider reducing the strength of the USAF in Europe, and France's refusal to accept nuclear-armed fighter-bombers on her territory encourages such a move. For the moment General Norstad appears to have been successful in postponing this project, but if some American units are one day withdrawn, then Western Europe will have to increase its contribution to the common defence effort.

•

In the air transport field, technological progress, though considerable, has not yet had such serious repercussions. IATA's traffic figures for the third quarter of 1959, recently published, show a 12 percent increase in North Atlantic passengers compared with the same period in 1958. Load factor, too, rose from 68.8 percent to 72.2 percent. This is comforting news. Speaking to the IATA Annual General Meeting in Tokyo, Sir William Hildred recalled that 1958 had been a bad year (chiefly because of the American recession) and that a growing number of large jet airliners would be coming into service during the coming months. Soon there will be 300 jets, capable between them of carrying more than half the traffic now handled by the entire world's air fleets. Hence the air transport market must be increased at all costs, by attracting a new clientèle and by making a determined attack on the air freight problem. The market, of course, is not unlimited. All the experts agree that traffic demand on the routes to Africa and the Middle East will increase considerably, but that the increase will be less spectacular for North America and Europe. But it is North America which provides the major part of the market, with four times as many passenger-miles as Europe and more than half the world total (excluding the USSR and China). Some kind of balance will therefore have to be found during the next two years between the capacity of the new jet aircraft and the size of the traffic available. Fortunately, there is no need to fear a new technical upheaval within the near future. Aircraft manufacturers appear to be willing to give operators time to amortize their new equipment, since there is to be no Mach 2 stage, and we shall probably jump straight from today's subsonic transports to aircraft cruising at three or four times the speed of sound.

Perhaps never before in the history of aviation have scientists and engineers on the one hand, strategists and operators on the other, had so many serious problems to solve. Add to this the conquest of space and the rivalries it engenders, and it will be seen that the programme before us is as vast as are the resources of technology. ***

INTERAVIA Essay Competition

It will be recalled that in mid-1958 *Interavia* organized an international essay competition, the prizewinners of which were announced during the 1959 Paris Air Show.

In response to the wish of the late Dr. E. E. Heiman, Founder and Editor-in-Chief, *Interavia* has decided to repeat the competition in 1960 and to award an

E. E. Heiman Prize

during the 1961 Paris Show. Rules for the competition will be published in the June 1960 issue of the Review.

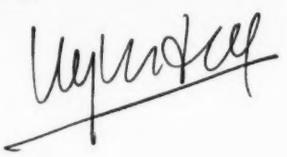
Jet Transport in 1960

By Max Hymans, Chairman, Air France, Paris

The jet age is rapidly becoming a reality, and for the past year the world's major airlines have been speculating on the future prospects of jet transport. Today Boeing 707s, Douglas DC-8s, Comets, *Tu-104s and* Caravelles *are plying on practically all the world's air routes, and the reception which the public has given them is reflected in the airlines' traffic figures. Several hundred thousand passengers have already travelled by* Caravelle, *which has been in service for seven months and is now operating to 28 points in Europe and the Near East. The Boeing 707s in service are between them producing an average of nearly 1,500 million passenger-kilometres a month.*

The constantly growing number of tonne-kilometres available and performed bears witness to the high qualities and performance of these new twin-jet and four-jet aircraft. This justifies the substantial sacrifices the airlines have had to make in order not only to buy their new equipment but also to operate and maintain it.

New prospects are opening up to air transport in these early days of the jet age; we believe that the increase in productivity of the new fleets will lead to a reduction in fares and hence to a "new wave" of passengers and tourists on all routes. Yet at the present time, when these prospects are barely beginning to reveal themselves and when the expenses to which the airlines have already committed themselves are far from having been amortized, we must beware of confusing the issue by talking of further new fleets, new systems of propulsion, new methods of navigation as if they would be with us tomorrow. Air transport, like nature, must not make sudden leaps ahead.



Civil Aviation in the West

By Derek D. Dempster, London

When BOAC and Pan American World Airways introduced the *Comet* and the Boeing 707 into airline service just over a year ago, the future of commercial aviation rested largely on the success the new airliners made of their first twelve months in operation. Despite some gloomy forecasting, there have been no major disasters, and by and large the new equipment has acquitted itself extremely well, even though some nasty incidents dulled the first rays of what some say should be the "Golden Age" of aviation. Golden Age or not, in their wisdom most operators have been keeping their fingers firmly crossed, and they could not do better than to keep them that way for some time to come.

Though relatively few in number at this juncture, jets have undoubtedly caught the imagination and, contrary to expectation, they have not only managed to fill themselves, they are attracting an ever widening public to accept air travel as the best way of getting about.

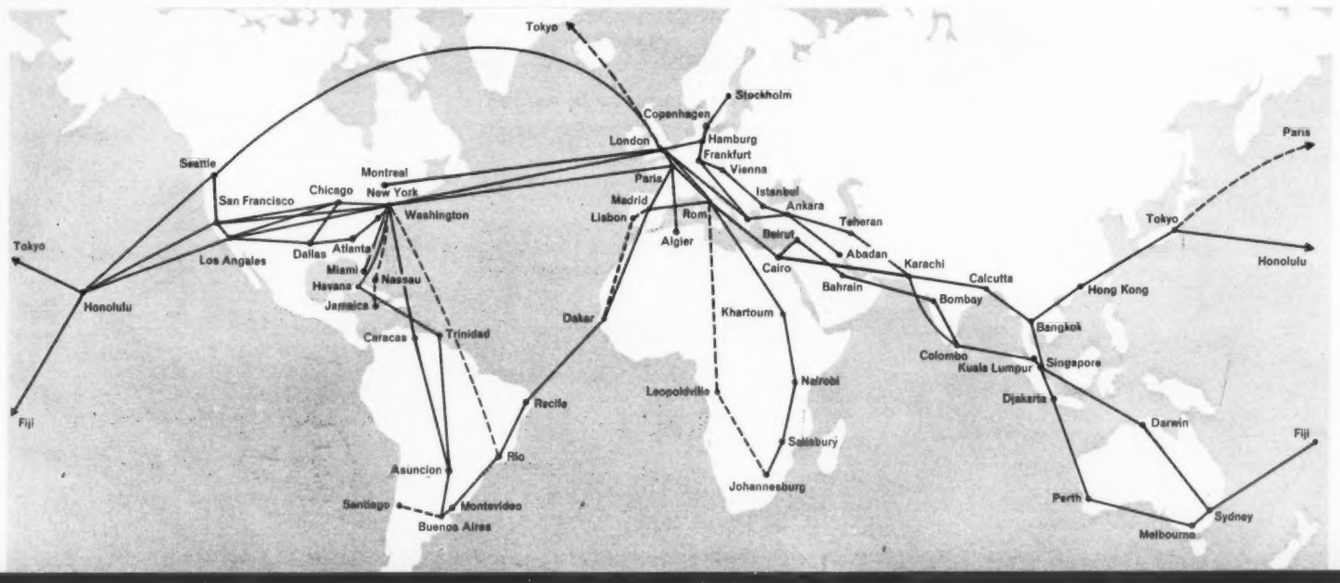
Despite this trend, however, the airlines are not in for an easy time; they are going to have to work damned hard to maintain the high load factors they need to face the hot competitive climate which threatens to become positively oppressive in the years to come. With more than 300 big jets costing $5 million apiece bespoke, and horrendous losses on the sales of still perfectly sound piston engine equipment, this isn't surprising; as a result we are witnessing today some vigorous bids to get out of the hole the airlines readily confess they have dug for themselves in the competitive re-equipment scramble.

Strangely enough the most obvious remedy to this overreaching has not been as widely adopted as expected; only a handful of American operators have cut back on original orders, although the French Government insisted on the French independents, UAT and TAI, reducing their projected orders for DC-8s from four apiece to a total of four.

The same capital saving principle was adopted in Australia when the Government —in all its wisdom, Heaven knows why!— ruled out TAA's preference for the *Caravelle* and placed an upper limit on the number of *Electras* Australian carriers could order.

On the other hand, the need to fill increased capacity and trim costs has led to the adoption of some more positive policies. A big drive is on to exploit the freight market which looks like stemming the pressure of events and

The jet route picture as the new decade opens: The major long-distance routes being operated by jets on January 1st, 1960 are shown by unbroken lines, those projected for the first three months of the new year by broken lines. The longest of these routes runs right round the world, the shortest which could be shown on the map from Paris to Algiers. (For obvious reasons it was not possible to indicate all the routes inside Europe or the United States.)



helping the airlines over their immediate difficulties. The move is long overdue. Present indications are that this drive is meeting with marked success although the potential available has barely been scratched. Latest figures show an increase in cargo tonmiles over 1957, and that trend is expected to continue.

The trend towards the conservation of capital and consequent reduction of capital requirements has manifested in a number of other directions. The Swissair-SAS equipment interchange and engineering agreement is a case in point, more or less paralleling National Airlines' contract to lease Boeing 707s from Pan American during the winter and to exchange stock with the latter.

Further examples of capital rationalization are the agreements between East African Airways, Central African Airways, Ghana Airways and Nigerian Airways on the one side, and BOAC on the other. By chartering modern aircraft from the Corporation the smaller airlines are able to obtain a given capacity with a smaller capital commitment than would otherwise have been possible.

But perhaps the most ambitious cooperative plan yet is Air Union, embracing Air France, Alitalia, Lufthansa and Sabena. Coming into action in April this year (1960), initial emphasis will be placed on the coordination of the commercial side, to be followed by a rationalization of equipment and engineering. Nor is this rapprochement a unique flash in the pan! Air Union has brought respectability to the collaboration of the bigger powers on matters of air transport, and this year will undoubtedly see the development of similar British Commonwealth, Middle East, Asian and African arrangements.

What progress will be made on reducing fares during the 1960s is difficult to forecast if any form of discipline is maintained by IATA members. Broadly speaking there will be disagreement, with the majority vote supporting a "hold fast" policy. And yet, one cannot help but sympathise with the "fare cutters." No one has ever spoken more sense than Sir William Hildred when he said that fares were like a dam which, if lowered just a little bit, would release a substantial volume of new business. The question is how to drum sense into some people? Unfortunately it is almost impossible to break through policies motivated by emotional impulses stimulated by fear.

If discipline within the IATA ranks breaks down, however, the future will belong to those with the longest and sharpest knives; the smaller operators—and some big ones—will simply have to return to bush flying—or forget once and for all that the Wright Brothers ever invented the aeroplane!

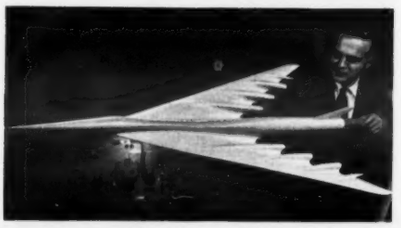
The airlines' financial dilemma is further accentuated by technical difficulties. Aircraft development has forged ahead at such a pace in the past 20 years that the modernization of ancillary services has constantly lagged behind, with the result that the airlines are still not able to make the maximum use of the commercial potential inherent in the big jets,

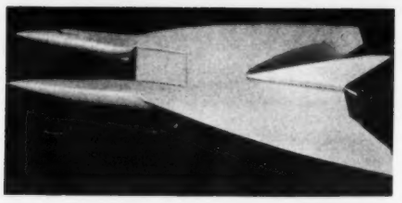
Jet airliners

1960...

Above, two representatives of the long-range jet transport: Convair 880 and Douglas DC-8 (over San Francisco). Below, the de Havilland *Comet 4*, Boeing 720 and Sud-Aviation *Caravelle* short-to-medium haul models.

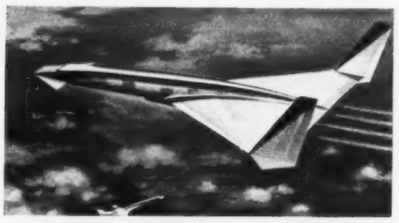
...and 1970?

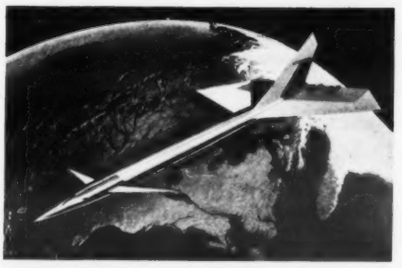




Research work on supersonic transports is well under way: R. T. Whitcomb, the American author of the area rule, examines with a connoisseur's eye the wind tunnel model of a six-jet area-rule Mach 3 aircraft (outside the transonic tunnel at NASA's Langley Research Center). Below, model of a Mach 3 aircraft, with double fuselage and jet-plus-ramjet powerplant as proposed by R. R. Jamison (Bristol Siddeley Engines).

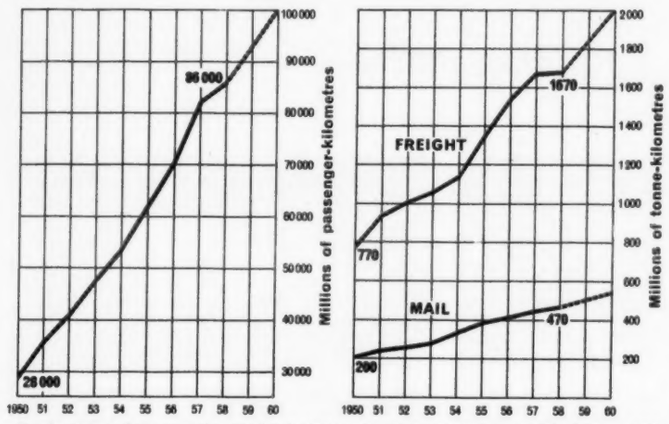
The manufacturers, too, have been equally busy: below, proposals by Convair (R. C. Sebold) and Lockheed (Hall L. Hibbard) for Mach 3-plus transports of canard configuration.



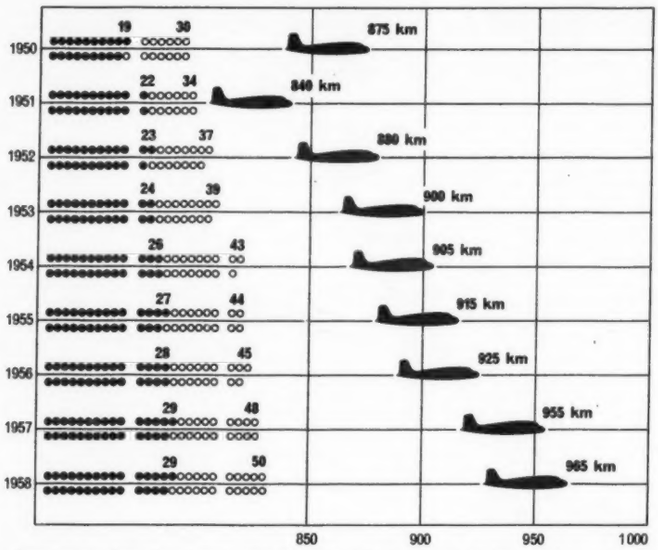


Supersonic stewardess with subsonic propeller: For the coming "supersonic season" KLM has prepared an attractive creation for female crew members (designer Gerson Dreese, model Hettie Weiling).

1960, Position and Heading



Productivity of the world's scheduled airlines (excluding USSR and China) from 1950 to 1958, from ICAO statistics: left, passenger volume (in millions of passenger-kilometres); right, freight and mail (in millions of tonne-kilometres). The number of ICAO member States rose from 55 in 1950 to 74 in 1959. The curves have been extrapolated to 1960.



Average number of passengers (black dots) and unsold seats (white dots) per aircraft, and average distance (in kilometres) travelled per passenger from 1950 to 1958 (ICAO statistics).

Order Book Jet and Turboprop Passenger Transports

ON ORDER AND DELIVERED AS AT 1st DECEMBER 1959

Type	Total Ordered	Customers (numbers delivered in brackets)	In service	
			Airline	Non-airline
JETS — Long/Medium Haul				
BOEING 707	152	Air-India 3. Air France 17 (1). American 26 (24). BOAC 15. Braniff 5. Continental 4 (4). Cubana 2. Lufthansa 4. Pan Am 29 (17). Qantas 7 (7). Sabena 5. SAA 3. TWA 27 (17). Varig 2. MATS 3(3).	70	3
BOEING 720	46	American 25. Irish Air Lines 3. United Air Lines 18.	—	—
CONVAIR 880/600	85	American 25. Capital 7. CAT 1. Delta 10. REAL 3. Swissair 7. SAS 2. TWA 30.	—	—
DOUGLAS DC-8	150	Alitalia 4. CPAL 4. Delta 6 (6). Eastern 16. Iberia 3. JAL 4. KLM 12. National 3. Northwest 5. Olympic 2. Pan Am 17. Panair 4. Panagra 4. Philippine Air Lines 2. SAS 7. Swissair 3. TAI 2. TCA 10. UAL 40 (11). UAT 2.	17	—
DE HAVILLAND DH. 121	24	BEA 24.	—	—
DE HAVILLAND COMET 4	39	Aerolineas Argentinas 6 (3). BEA 7 (2). BOAC 19 (17). CMA 3. EAA 2. Olympic 2.	22	—
SUD AVIATION CARAVELLE	55	Air Algérie 4. Air France 24 (7). Alitalia 4. Finnair 3. Royal Air Maroc 1. SAS 17 (5). Varig 2 (1). (N.B. Sabena order for 4 officially announced on December 14th)	14	—
VICKERS VC. 10	35	BOAC 35.	—	—
TURBOPROPS — Long/Medium Haul				
BRISTOL BRITANNIA	83	Aeronaves 2 (2). Air Charter 2 (2). BOAC 33 (33). CPAL 8 (8). Cubana 4 (4). El Al 4 (4). Hunting Clan 2 (2). Transcontinental 2 (1). Min. of Supply 3 (3). RAF Transport Command 23 (8).	56	11
LOCKHEED ELECTRA	172	American 35 (24). Ansett-ANA 3 (2). Braniff 9 (8). Capital 5. Cathay-Pacific 2 (2). Eastern 40 (40). Garuda 3. KLM 12 (3). National 15 (12). Northwest 18 (7). Pacific S. W. 4 (1). Qantas 4 (3). TAA 2 (2). TEAL 3 (1). Western 12 (5). Transamerican Aeronautical Corp. 2. Commercial Firms 2 (1). U.S. Navy 1 (1).	110	2
VICKERS VANGUARD	40	BEA 20. TCA 20.	—	—

Note: Short and medium haul turboprops are not included in the table. Main details are as follows: Fairchild F-27: total 78 ordered, 47 already in airline operation; Fokker F.27 *Friendship:* 58 ordered, 20 in airline operation; Handley Page *Dart-Herald:* 3 ordered; Hawker Siddeley Avro 748: 6 ordered; Vickers *Viscount 700 Series:*284 ordered and delivered, 264 in airline operation; Vickers *Viscount 800/810:* 124 ordered, 122 in airline operation.

and they will not really be able to until international agreement on facilities, services and procedures for jet operations has been reached and implemented.

In many parts of the world where the big jets could be very profitably employed, the facilities needed—suitable navigation and approach aids and adequate runways—are not available. Local procrastination and indecision fanned by nationalism in the face of foreign offers of assistance are at the root of the trouble. On reflection it is unbelievable, since the knowledge required to develop the most comprehensive services for the jet age has been available since the *Comet 1* began pioneering turbine flight in the early 1950s.

The repercussions are indeed interesting. A number of operators have privately admitted that in ordering the big American jets they made a mistake. They are, in consequence, looking at smaller equipment like the *Comet* with watering mouth and green eye. Meanwhile the uncommitted airlines have been watching from the touchline, and this year will see them finally signing up for equipment. It is by no means certain that it will be of the wing podded engine type!

Inside the cockpit an equally difficult situation exists. Contemporary jets are being flown on the same old instruments that have been used for years in aircraft like the DC series, the *Constallation* and the *Viscount*. And yet, pilots are expected to operate with the same degree of safety with which they flew the earlier birds.

If we take the gyro-horizon, for example, we find that longitudinal acceleration of high speed aircraft affects it so severely that it cannot be relied upon to give a true interpretation of attitude during take-off in the latest aircraft. This is further aggravated by the fact that such acceleration causes swirl in the human brain so that a pilot is prevented from interpreting the readings of his horizon correctly.

The classical night take-off problem of sensory confusion between acceleration and climb, which has caused so many accidents, can be accentuated by increased acceleration, higher speeds and, in some cases, lack of control feel in jets. So, on a dark night devoid of outside visual clues, a pilot must ignore strong sensory illusions if he is to make a successful take-off.

Now although the airlines are making big efforts to solve their problems by taking sound, rational steps, their chances of success could well be retarded by those who see salvation shining brightly through the sound barrier. Among them is Continental Airlines President,

Robert F. Six, who is plugging for aircraft still faster than the current crop of jets.

"Aircraft for supersonic transport can be built today," he says with apparent conviction, "for about $13 million a plane, compared with $5 million for a 707 or a DC-8. We intend flying them in 1967."

Six is not the only man to hold this view. There are others, particularly in the aircraft industry, who don't want to get caught with their pants down as they were with the *Comet 1*. As a whole the airline hierarchy is not going along with him, however, and it is resisting industry's lobbying for supersonic transports before the end of this new decade.

Sure enough, the supersonic age must come, but it would be the height of folly to precipitate ourselves into it before we have squeezed the subsonic lemon dry! It may have a sour taste today, but not half as sour as if left half squeezed.

Among those who go along with this view is American Airlines' President, C. R. Smith, who believes supersonic jets are too expensive to develop without Government help. But this is unlikely to be forthcoming, as the United States Air Force is showing little interest in assisting such a project.

Donald Douglas goes even further. He questions the wisdom of switching from a 600 m.p.h. aircraft to one capable of flying at 1,800 m p.h. when it is possible to go hypersonic in a rocketpropelled vehicle at 10,000 m.p.h. That, he says, is not impractical in our lifetime. And assuming that he means within his own lifetime, the healthy sixty-five year old Douglas must be reckoning on the hypersonic aircraft being available for public transport fifteen years from now.

Fifteen years is perhaps longer than the airlines anticipate operating the aircraft that are coming into service now. Nevertheless, the prospect of stability over that period of time must surely be attractive, for it would enable them to develop the solid financial background they so desperately need and give the less developed countries time to implement the airfield, navigational and approach aid improvements they seem to be having difficulty in financing at the present time.

If we examine the reasons for Donald Douglas's views, it would be difficult not to agree with him, for the problems facing the supersonic aircraft designers are not only financial, but technical. He estimates that the development of the supersonic jet would cost about five billion dollars at present costs, and no aircraft manufacturer has that much capital to risk on enterprises of this nature.

Douglas admits quite freely that his company has lost money so far on the DC-8, although he hopes to recoup these losses as more and more of the planes are turned out.

World Air Transport 1956—1959 and Prospects for 1960

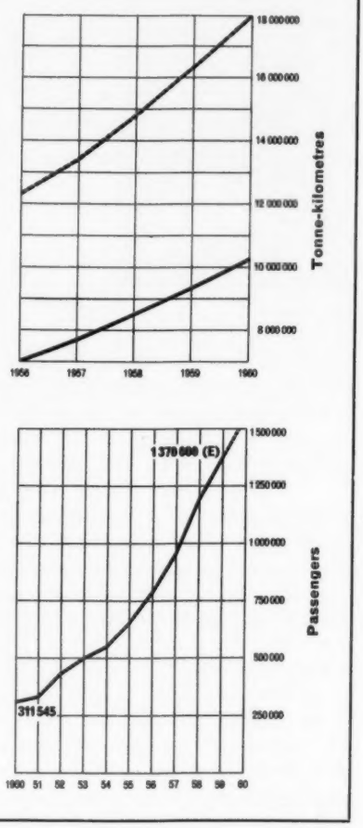
How air transport will grow in the next twelve months is not easy to forecast. Because more than half the total world air traffic is generated in the United States, and the Americans suffered a recession in 1958, the overall average upsurge was checked. Therefore any increase recorded in 1958 over 1957 or in 1959 over 1958 will not be representative of the natural trend.

Although it has been generally accepted that a 15 percent annual increase is the normal figure, an average of ten percent would be more in keeping with the natural facts. Therefore any increase in traffic over and above this figure must be achieved by means of fare reductions, salesmanship or other beneficial factors.

The broken line in the upper diagram shows the available tonne-kilometres (passengers, freight and mail), the unbroken line the tonne-kilometres performed, in both cases with extrapolation to 1960 based on an annual rate of increase of 10 percent.

This annual increase is not sufficient to cover the financial needs of the airline industry. A substantial rise in the lower curve is urgently needed... Or, as IATA Director General Sir William Hildred put it in his annual report for 1958: "We shall have to feed progressively larger gobbets of traffic to these monsters, or they will eat us up, capital and all."

By contrast, the volume of scheduled air traffic across the North Atlantic (lower diagram) reveals a more encouraging development. The number of passengers carried rose from 311,545 in 1950 to 1,193,213 in 1958 and can be expected—on the basis of the figures for the first three quarters of the year—to be roughly 1,370,000 for 1959. If this trend continues, North Atlantic passengers may well number more than 1,500,000 in 1960.



Assuming a fifteen-year stability, it could well be that his company will repeat the piston DC series story by progressively developing the DC-8[1], so that by 1975 at least 1,000 of these aircraft and their progeny will be operating on the world's routes.

With an equal distribution of other types now scheduled to roll out of the aircraft factories of the world, this makes sense. For not only will the facilities and services required for the jet age be able to mature, the stability provided ba such a peaceful period will enable the airlines to pass on their accruing benefits to the travelling public.

But unless the airlines cry halt this year, they are going to be involved in a scramble from which many will never emerge. This year of grace, 1960, is a year of decision. By the Grace of God let's hope they make the right one; a decision further complicated by the fact that we have not any idea what the Russians are doing. ◆◆

[1] Douglas is already reported to be planning a *Super DC-8*, with longer fuselage and accommodation for up to 200 passengers. Ed.

A Trans World Airlines Boeing 707-331 at San Francisco International Airport.

Soviet Civil Aviation and Its Future

By Yevgeni Loginov, Head of the Central Administration of the Civil Air Fleet, Moscow.

I should first like to thank the editors of Interavia *Review for kindly inviting me to give their readers a report on the development of civil aviation in the Soviet Union. In accepting, we knew very well that it was impossible to deal with all the aspects of Soviet civil aviation in a single article. But we feel sure that even the little we can tell* Interavia *readers will contribute to mutual understanding, encourage contacts and promote the caurse of peace and friendly relations.*

The vast territory of the Soviet Union, which covers a sixth of the globe, the extraordinary variety of economic, geographical and climatic conditions in different parts of the country, and the need for maintaining closely knit contact between these regions, make severe demands on the transport system in general and air transport in particular.

In 1959 the Soviet Union embarked on a seven-year plan for economic development, which includes projects for considerable expansion in air transport. Our present aim is to make the aircraft the principal means of passenger transport by 1965, and for this reason the rate of expansion envisaged for air traffic volume is higher than that planned for other means of transport, namely 31 percent per annum. In each of the next seven years we shall be carrying nearly a third more passengers than in the previous year. The very fact that for 1964, the last year but one of the the seven-year plan, the growth in traffic volume alone is expected to equal the total volume carried on all routes in the USSR in 1958, is in itself an indication of the rate of development of Soviet air traffic. As a result of the seven-year plan Aeroflot will by 1965 be carrying six times as many passengers and four times as much freight and mail as in 1958.

These figures give a general idea of the future of Soviet civil aviation, the trends in its development, and the efforts we are making to improve service to our people and our country's economy by the fastest and most comfortable means of transport.

A CSA Tupolev Tu-104 in front of the terminal building at Moscow-Vnukovo, one of the Soviet capital's three airports.

An Ilyushin Il-18 turboprop aircraft at Adler Airport, on the Black Sea. In the rear is the terminal building (note unusual architecture).

About forty Aeroflot turbine-powered aircraft lined up at Vnukovo for scheduled services. *Row at left,* from left to right: an Il-18 turboprop aircraft and three Tu-104 jets; *in rear* are an Ii-18, several piston-engined Il-14s and an Antonov An-10 high-wing turboprop aircraft; *middle-row:* two Ilyushin Il-18s and three Tu-104s; *far right:* two Tu-104s, and an Il-14 and (in rear) half a dozen more Il-14s. On the perimeter of the airfield are a good dozen Tu-104s and five or six Il-18s...

A giant takes to the air... and draws in its undercarriage: a Tupolev Tu-114 turboprop airliner for 170 to 220 passengers.

At the same time it is planned to extend the special branches of civil aviation: agricultural and forestry work, aerial photography, prospecting, and the control of forest fires over widespread areas. In 1965 our agricultural flyers will have to treat about 86 million acres, i.e., twice as much as in 1958. It is also planned to make more extensive use of aircraft for forestry protection than hitherto, and for this purpose new fire-fighting systems using aircraft and helicopters are being developed. Aerial photography and prospecting programmes are planned to cover a vast territory with an area of several million square miles.

*

The *longest air route* in the Soviet Union runs from west to east and is over 5,000 miles long. It crosses the most important economic zones in central Russia, the Urals, Siberia and the Far East, connecting all their major cities. Add to this the many branch routes linking airports on the east–west artery with towns in the north, south-east, north-west and other geographical regions, and the network is at least two or three times as long as the direct route. The *shortest air route* in the Soviet Union, Moscow–Leningrad, is about 440 miles long. In addition, the Republics, areas and provinces of the Union have numerous domestic networks which ensure year-round communications between industrial, cultural and administrative centres. Finally, under agreements with foreign airlines, Aeroflot runs various international services.

To ensure the fulfilment of the seven-year plan our civil aviation system is undergoing thorough technical revision. In particular, the fleet is being continually increased by the purchase of modern jet and turboprop aircraft. Aeroflot is still acquiring twin-jet Tu-104s developed by a group under the direction of the well-known aircraft designer A. N. Tupolev. These aircraft have been in scheduled operation on several of Aeroflot's routes for over three years, though while the Tu-104s we had in 1956 would take only 50 passengers, those in service today have seventy- and hundred-passenger layouts. In addition, Aeroflot is receiving increasing numbers of Il-18 and An-10 turboprop airliners. We shall also soon be receiving the new Tu-114s for 170 to 220 passengers.

*

Articles and reports in the foreign press are unanimous in praise of the Tu-104's flying qualities, but continually point out that this type will not be profitable to operate. Here I should like to state very emphatically that profit-making is not our aim. When we put the Tu-104 into service revenue was the last thing in our minds; our one idea was to make it possible for our passengers to travel long distances in the shortest possible time and the maximum comfort. This does not, however, mean that we neglect the question of economy and profitability of operation. The Tu-104 is at present in scheduled service on 33 domestic and international routes. The load factor has risen sharply, resulting in a considerable reduction in fares.

In the long run modern turbine-powered aircraft make air travel not only easier and more comfortable, but also cheaper. Small wonder that the inhabitants of Vladivostok, Petropavlovsk-Kamtchatski, Khabarovsk and other remote cities have recently been choosing the Tu-104 for their holiday trips to Black Sea resorts. Many tourists on excursions from Moscow to Leningrad and other cities also travel by air, preferably by Tu-104. On the Moscow–Leningrad route the Tu-104's average load factor is 97.5 percent.

Aeroflot's technical progress towards increasing passenger volume sixfold by 1965 is also shown by *improved ground services*

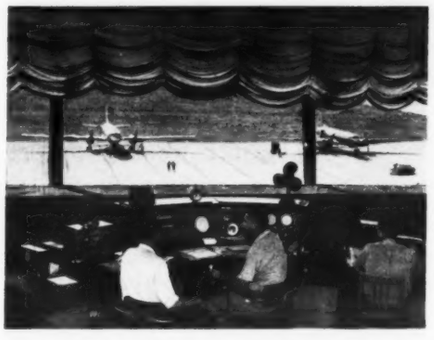
A Tu-104A lands in the snow with brake parachutes.

Main entrance to Tashkent Airport in the Uzbek SSR.

A New Gateway to Moscow

The Soviet capital has just opened its third airport, *Sheremetyevo,* which lies in the heart of wooded country some twenty miles from Moscow.

Each day more and more aircraft arrive at Moscow from the cities of the USSR and abroad, and large-capacity jet and turboprop aircraft have recently gone into service on many new routes. Traffic between Moscow and foreign capitals is expanding continually, and the flood of passengers is rapidly increasing. Small wonder that it was found necessary to build a third airport to ease the load on Vnukovo and Bykovo, the two already in operation.



Above: Control tower at Moscow-Sheremetyevo (with dispatchers I. Yeroshkin and A. Krivorutchenko, and, to the right, controller P. Ratsko); below: luggage handling equipment and bus for transporting passengers direct to the city centre.

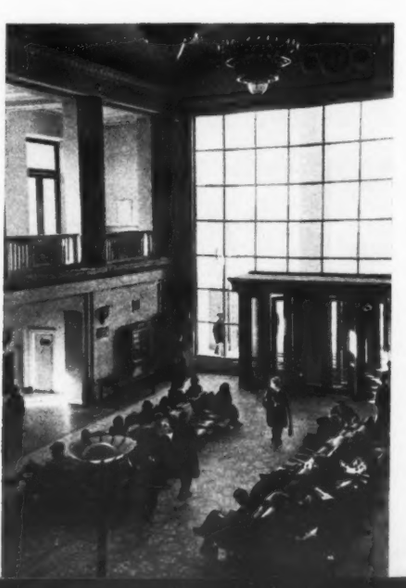
Aircraft land on a runway built to meet the most modern requirements and come to a halt in front of the three-storey terminal building, which is laid out in the usual way with waiting rooms, offices, restaurant, ticket counters, sleeping quarters, post, telephone and telegraph office, hairdresser etc. The control tower is in a glass dome on the roof.

Passengers whose destination is Moscow itself are taken to the city centre by special bus while, after a short rest, transit passengers climb aboard Li-2 "flying taxis" for one of the two other airports.

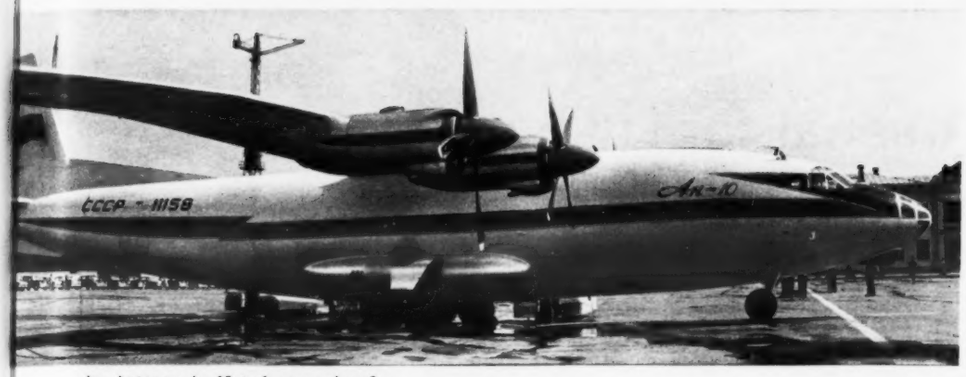
At present, flights from Sheremetyevo serve Leningrad and Kiev, but the services from Moscow to Tiflis, Vilna, Riga, Reval and other cities in the Soviet Union will be transferred to the airport at a later date.

Work is now in progress on a second building which, when complete, will make Sheremetyevo one of the largest airports in the Soviet Union.

The waiting-room at Tashkent Airport. ▶



Snapshots of Aeroflot's flight personnel. Left to right: Captain Boris Bugayev at the controls of his Tu-104A: stewardess Tamara Khrolenko in the passenger cabin and stewardess Nina Baranova in the galley.



An Antonov An-10 turboprop aircraft.

Entrance to Vnukovo Airport hotel, Moscow.

Room at an airport hotel.

Terminal building at Alma-Ata in the Kazakh SSR.

with a view to ensuring strict observance of timetables, a high degree of safety and rapid passenger and freight clearance. The seven-year plan provides for the construction or modernization of over 90 airports on routes of nation-wide importance. The new or reconstructed airports will have runways for large airliners, modern air traffic control equipment, maintenance hangars with docks for inspection and overhaul, and comfortable waiting-rooms for passengers. At the beginning of August, 1959, Sheremetyevo Airport, Moscow's third, was opened, and the reconstruction of several airports, including Irkutsk, Khabarovsk and Alma-Ata, is nearing completion. New airports have been laid out at Baku, Odessa, Vladivostok, Sukhumi and Krasnodar. It is also planned to increase the number of airports on local routes. Finally, in Moscow, Leningrad and Kiev, there are plans for building town terminals; here fast buses will take passengers directly to their aircraft in 10 to 15 minutes.

*

What does all this add up to?[1] In the first seven months of 1959 Aeroflot carried 44 percent more passengers and 50 percent more freight and mail than during the same period in the previous year, thus exceeding the target. Agricultural operations also beat the target figures: from January 1st to September 1st, 1959, over 42 million acres of crops were treated, as against 44 million for the whole of 1958. It is in Aeroflot's day-to-day work that our plans are put to the harsh test of reality, and the results achieved have shown us that it is possible to complete our programme ahead of schedule. ⟷

[1] Articles by Soviet civil aviation experts in forthcoming issues of *Interavia* Review will deal with Aeroflot's international services and domestic routes, polar flying, air traffic control in the Soviet Union, fleets, technical services, training schools and personnel. Further articles will be devoted to pest control and sports flying.

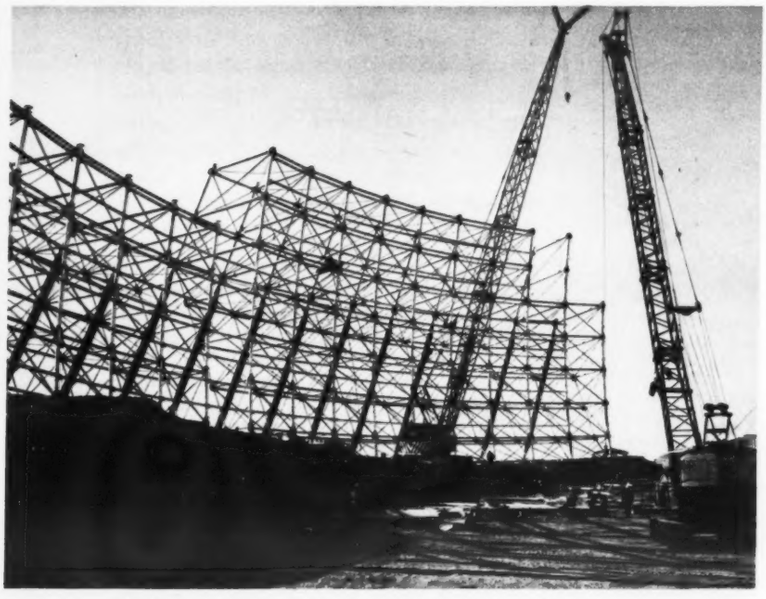
Editors.

Moscow-Sheremetyevo: the Tu-104 arrives from Leningrad.

An Arsenal for Lasting Peace

By Pierre M. Gallois, Paris

"A good horse which is also cheap is rare. That which is rare is expensive. Therefore a cheap horse is expensive." This famous syllogism, designed to put young philosophy students on their guard against the perils of dialectics, was committed—quite unconsciously—by a military personality of the West, who wrote, in substance: "The destructive power of nuclear weapons is such that large-scale warfare is practically inconceivable. Therefore they will not be used. And since they are very expensive and will not be used, they should be dispensed with." The absurdity of this proposition is not evident to all. Yet it is the very existence of nuclear weapons which determines the *status quo* and which deters a would-be aggressor from resorting to blackmail or to war itself. To get rid of them would mean a return to the conditions which have plagued humanity from Crécy to Hiroshima. Was the age of TNT so remarkable for its benefits that we should long for its return? Did it bring such long centuries of peace as to be so vastly preferable to the atomic age?



A web to trap ballistic missiles: In the Far North of the American continent 1,400 men are working night and day to erect an electronic early warning system. Mighty antennas will pick up enemy ICBMs 3,000 miles away, giving defenders 15 minutes' warning.

Experience teaches us that, as long as sources of conflict exist—and unequal distribution of wealth among the peoples of the world will be a source of conflict for years to come—we must have a complete arsenal at our command. If it is lacking in as much as one weapon, it is with that weapon that the enemy will attack. This applies equally in the case of all-out thermonuclear war, conventional conflict, "local" disturbances, subversion or political and economic warfare. Even if general, total and controlled disarmament were ever achieved, there would still be political absolutism and the force of numbers to bring about the destruction of the countries which have reached a higher stage of social evolution and which, almost by definition, are the most divided and the least willing to make sacrifices.

This prospect, albeit disheartening, is nonetheless realistic, and it must be borne in mind in examining the evolution of strategic and tactical concepts in the new decade which will begin as we change our calendars. But such an examination must take account of the heritage of the past, the present situation and their probable effect on the future.

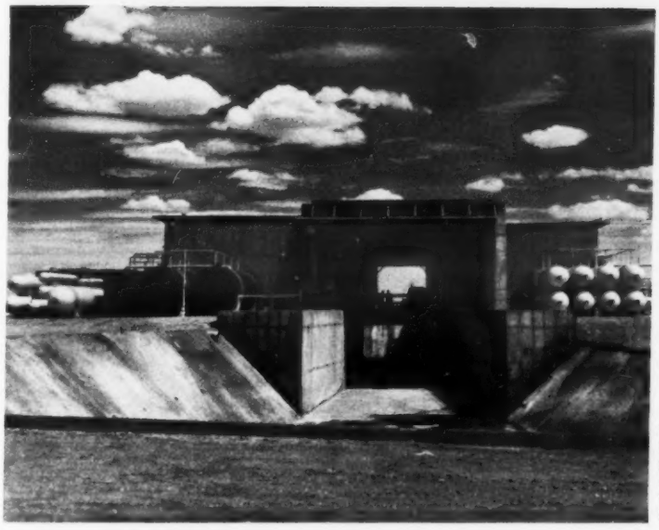
The basic fact is that the all-powerful (or almost all-powerful) nuclear explosive of limited size and weight has now become an operational possibility. The divisions which the free world has, with enormous effort, managed to mobilize are so alarmingly inferior in numbers that the West cannot abandon the inestimable advantages of high unit destructive power. If the USSR and China were to succeed in outlawing the nuclear explosive, these two great Powers—jointly or separately—would have such an advantage over even the most unshakable of Western alliances that the latter would be obliged either to knuckle under or face defeat in war.

It has been said that NATO forces could, if necessary, be equipped with weapons ranging from 0.5 kilotons to over 20 megatons, i.e. with a blast radius from about 1,000 yards to 8 or 9 miles; thus any degree of destructive power could be selected at will.

In September, 1958, physicists of the U.S. Atomic Energy Commission went into the Nevada desert to test charges of low explosive force equivalent to quantities of TNT below 100 tons. Although applications of these experiments have not been divulged, their importance is considerable. The moment a country has enough fissionable material at its disposal and commands a technique enabling it to "miniaturize" both the explosive power and the actual warhead, it can form a diversified atomic arsenal to meet nearly all the contingencies in which the use of force is required.

What is more, a new factor is introduced into the relationship between adversaries by the process of "going one better." Why should country A accept defeat under pressure from country B, when it has in its arsenal more powerful weapons capable of procuring an advantage? And why, in its turn, should country B resign itself to losing a war when it could be victorious simply by climbing to the next rung of the ladder and deploying a still more powerful weapon? And so on. A dispute beginning with tommy-guns or heavy artillery could progress through the various stages of destructive power and might, if both belligerents were possessed by the same degree of resolution, lead to an exchange of thermonuclear attacks. It has been said that all wars are senseless, but history has disproved this statement; the instigators of conflicts have sometimes gained more than they have lost. But today the process of "going one better" could continue to absurd lengths. That limited warfare on the scale of, say, a frontier incident, with rifles and tommy-guns, should be allowed to lead to a war waged with megaton bombs, is too wild a hypothesis to be at all plausible. And since both belligerents—assuming that each is in possession of a complete nuclear arsenal—know that they have either to yield—and who will be the first to do so?—or to follow the spiral of disaster into absurdity, negociation is vital right from the start. There is little difference between the most powerful chemical explosive and the least powerful nuclear one. If there is a dividing line between the two kinds of weapons, it is mainly psychological, since the atomic weapon adds the effects of radioactivity to the mechanical effects of ordinary explosive. But, if a country were faced with defeat, the line would probably be overstepped. Does this mean that war is impossible in the future? No, of course not. Incorrect assessment of the other side's reactions introduces an irrational factor and consequently the possibility of armed conflict. But the probability of a resort to violence has diminished; since the consequences of war are irreparable, the game is no longer worth the candle.

The prospects for peace can be improved only by a diversified atomic arsenal which will inspire fear of the mounting tide of destruction. Just as thermonuclear explosives act as deterrents to an open clash between the USSR and the USA, the low—and medium—power nuclear weapon will limit the risk of conflict and make the Korea type of war a thing of the past. Just as, for years to come, there will be strategic forces capable of restraining large-scale aggression, so the possession of an appropriate arsenal will extend the concept of deterrence to "local" wars which can lead to "all-out" conflict; no belligerent will face the latter, since it would lead to a general catastrophe in which both sides would be annihilated.



The bunkers for the first *Atlas* ICBM "semi-protected" launching site were built by the U. S. Army Corps of Engineers under contract to the USAF at Warren AFB, near Cheyenne, Wyoming.

The U.S. Army's new, highly mobile *Sergeant rocket* (with solid-propellant motor) can carry small atomic warheads over distances up to 600 miles.

Both camps are now building up formidable arsenals of small, medium and large weapons. There are thus, for instance, no less than a score of different missiles, American and British, which will take low-power atomic warheads. At the other end of the destructive scale, there are about 20 missiles and aircraft capable of transporting nuclear warheads from 1 to over 20 megatons.

The existence of nuclear power, as briefly described above, has at least three important consequences for weapon techniques and the conditions for their application.

1. The "dissemination" of American nuclear weapons on Western European soil. It is already over two years since this policy was adopted, and it has since materialized, at any rate in Great Britain, Italy and Turkey. The form of the agreement differs from country to country: in one case the principle of dual control is applied to actual equipment, the host Power providing the "carriers" and the United States the nuclear warheads, while in others U.S. forces are responsible for operating the entire weapons system, but cannot do so without the agreement of the government in whose territory the missile is based. But whatever the conditions of use of these nuclear missiles, their distribution in Europe is a vital factor in the West's power, and they will act as a possible substitute to Strategic Air Command.

It is clear that these missiles cannot be used from day to day as a means of influencing international relations. One can hardly conceive of Turkey, Italy, Great Britain or even the USA backing up their respective diplomatic policies with missiles, for no one would take very seriously a threat which could obviously never materialize. These weapons of mass destruction could be deployed only against the enemy's cities, and their use would amount to suicide, since it would unleash a crushing retaliation; they could be effective only in exceptional circumstances. The peril facing the Power in whose territory they are based would have to be exceedingly grave for it to prefer suicide to enslavement and resort to these weapons. But world tension would have to be very great before a country could find itself in such a predicament, and the aggressor would have to make allowance right from the start for the possibility that the United States would relinquish its nuclear control. Of course, this assumes that the USA would accept a certain degree of responsibility, but she has already done this in setting up missile bases in European territory. And since the aggressor could not afford to attack the United States in a dispute with the Power in whose territory the missiles are deployed, he would be compelled to abandon threats or the use of force, and the deterrent missiles, though initially under the control of two governments, would have played the same role as purely national weapons.

Titans can be fired from underground launching silos such as this one at Vandenberg AFB, California.

As things are at present, and having regard to the resources at the disposal of the European nations, jointly or separately, dual control of missiles is the most realistic solution to the problem of discouraging local aggression. In the case of large-scale aggression, the contribution which these weapons can make is obvious.

But if the deployment of American IRBMs in Western Europe is to be an effective guarantee against the use of force, it must be possible for the missiles to survive initial attack. Calculations have shown that, with the accuracy now obtainable (1 to 3 thousandths of the distance for 50 percent of the missiles launched), and with the crater effects produced by IRBM warheads of 1 megaton and over, only a small number of offensive missiles would be required to paralyze a country's reprisal force, even if its missiles were kept under concrete. If the enemy's launching ramps are less than 2,000 miles away, it is better policy to rely on mobility rather than on underground bases. To keep the aggressor ignorant of the positions of targets which it is vital for him to hit appears to be the main task of an effective deterrent. In the race between the aggressor striving to increase missile accuracy and the defender hastening to protect his missiles by concrete, the odds are all against the latter. Even at the cost of a longer reaction time and reduced precision, techniques for improving mobility seem more appropriate to Europe than those providing for static deployment.

2. The priority requirement of missile survival is inherent in the concept of the lightweight strike fighter.

Faced with the numerical inequality of the conventional forces in being, NATO has been compelled to announce that, in the event of aggression—whatever form such aggression might take—the West would retaliate with nuclear weapons. To use these new weapons on European soil meant deciding on a complete strategy and on the characteristics of the necessary equipment. Deployed as far east as possible, allied ground forces with aerial support would hold the line as long as they could, while the main forces were exchanging thermonuclear blows. But, to hold such a front despite numerical inferiority, NATO's ground forces would have to guard against infiltrators and avoid the close contact which the enemy would seek in order to prevent the use of atomic weapons. It was the examination of this particular problem which led to a definition of the performance required of the "first generation" lightweight strike fighter. It was essential to form light units whose aircraft could carry out armed reconnaissance missions in a narrow zone where parties of infiltrators and the beginnings of enemy concentra-

Two opposed camps are preparing a complete arsenal of large, medium and small nuclear weapons. The Republic F-105 *Thunderchief* all-weather fighter-bomber is among the aircraft designed to carry tactical atomic weapons of small and medium calibre. The picture shows the 334th Tactical Fighter Squadron flying in formation to Seymour-Johnson AFB, North Carolina.

tions must be destroyed at sight. But reconnaissance and strike aircraft would themselves have to avoid destruction. Vulnerability in flight would be reduced to a certain extent by low altitude penetration and, on the ground, by frequent changes in base. A light, relatively simple aircraft, capable of using rudimentary runways, was the result of these operational requirements. It must be admitted that, with the passing of months and even years, requirements became increasingly stringent, and the original aim was lost from sight.

Since then a "second generation" is under study, designed to fulfil the same mission more efficiently. It has the disadvantage of coming after various prototypes designed for vertical or short take-off, and military requirements are therefore strict. It will be recalled that in the United States, following tests by Lockheed and Convair, Dr. Alexander Lippisch did research work on a wingless aircraft powered by engines using jet deflection, while Bell's X-14, Hiller's X-18, Ryan's X-13 *Vertijet*, Kaman's K16B, McDonnell's XV-1 and Doak's Type 16, represented experiments with various formulae ranging from jet deflection to a combination of rotors and propellers. In Great Britain the Short SC.1, powered by five Rolls-Royce RB.108 jets, made its first flight as a conventional aircraft at Boscombe Down on April 2nd, 1957 (and its first vertical take-off last summer), while today the *Tyne*-powered Fairey *Rotodyne* is ready to go into production, and Hawker is completing its P.1127 powered by a Bristol Siddeley BE.53. The SNECMA VTOL helicopter, the Breguet 941 operating on the slipstream deflection principle, and the work of Marcel Wibault, are the most recent European contributions to research into vertical or short take-off. Tilting engines, orientations of jet flow by deflection or mechanical means, the use of one or more engines, vertical fuselage or tilting wings, all possible solutions have at least been envisaged, if not actually tried out. It is therefore hardly surprising that, on the basis of nearly a hundred separate studies, the military authorities have set the maximum requirements, demanding aircraft with both STOL characteristics and long range at low altitude, features which are difficult to combine in a single type.

Although of great interest to the civil carrier wishing to serve city centres, true vertical take-off is not essential for military operations, where a few hundred yards of level ground will always be available anywhere in the world for short take-off or landing. Similarly, though long range at low altitude is of great advantage in interdiction missions, this characteristic will fit an aircraft for applications other than those for which it was originally designed, at the risk of limiting the performance necessary to carry out the tasks which are its essential province. The danger is that the aircraft's original applications will be forgotten in the effort to give it a take-off performance similar to that of the purely experimental models created in recent years.

There is also a further consideration: the second generation of lightweight strike fighters, like the first, presupposes the use of nuclear weapons and the priority of missile survival. But, assuming that there will be a "marginal" clash—if such a hypothesis is still possible—during which belligerents will restrict themselves to the use of TNT, the speed and combat performance of this type of aircraft must be adequate for it to escape destruction and must not put it at a disadvantage in the face of more conventional equipment.

As for the powerplant, this, to judge from the interest shown by American specialists, will be a ducted fan like the fully developed Bristol Siddeley BE.53, suitable for short take-off or level flight at low altitude. The Hawker P.1127 is fitted with this jet. There will also have to be studies of the structure and surface treatment required for the hundreds of hours of low-altitude flight necessary for operational training. Since aircraft have had to seek at low altitudes the safety which, with the advent of the surface-to-air missile, they have lost at the tropopause and above, the problems of flying in a dense and turbulent atmosphere—and the ensuing fatigue—have come in for a considerable amount of study and resulted in a number of structural modifications (as in the case of the B-66 and B-58, to mention only bombers).

Nevertheless, at a time when many fields are closed to the aircraft and engine designer, military applications have opened up a new one. There will also be an opportunity for the electronic engineer to ensure that the strike aircraft becomes progressively capable of operating even in the poorest atmospheric conditions. Years of work lie ahead.

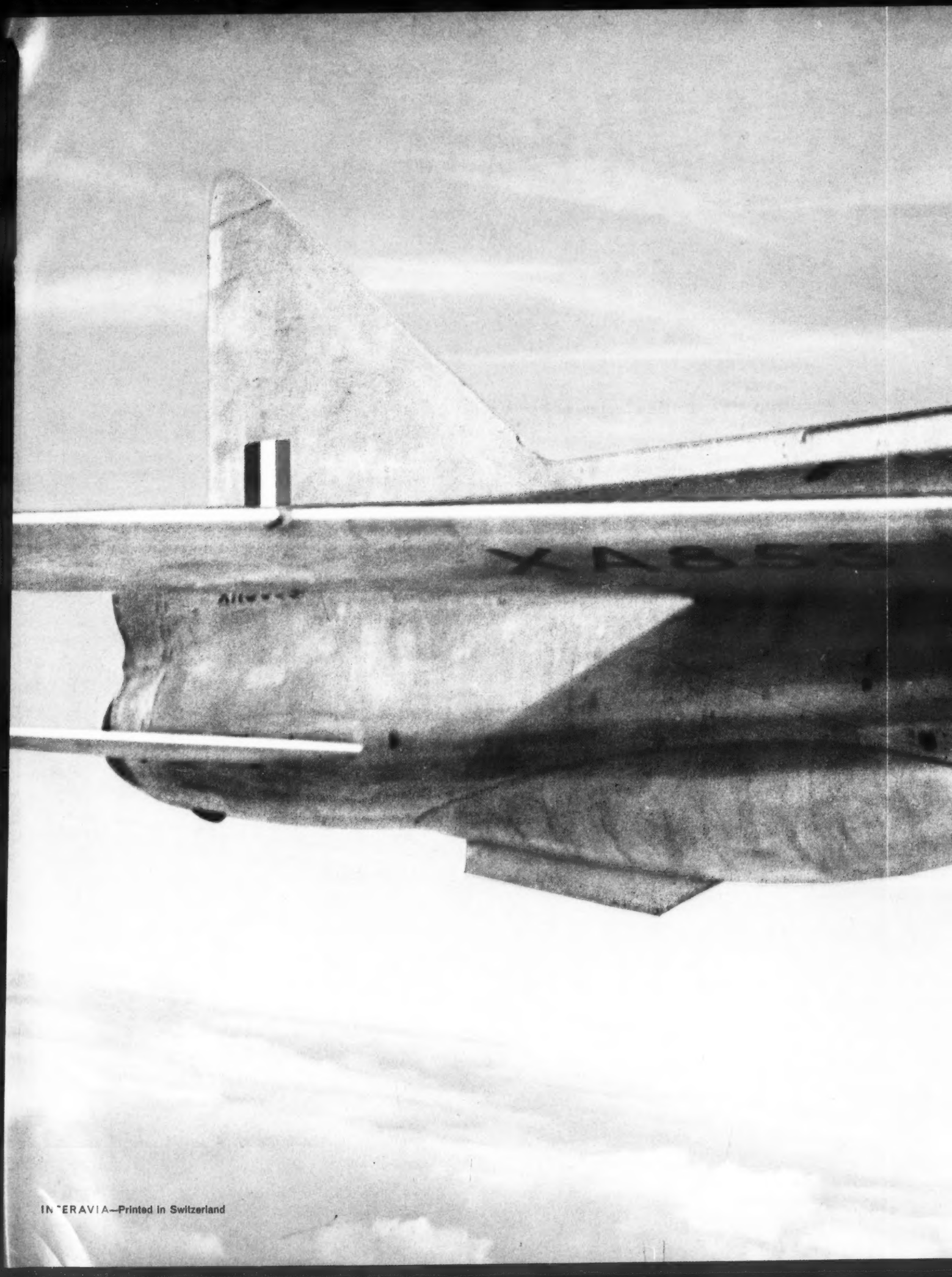
Speaking to the Air Force Association, General Thomas D. White, USAF Chief of Staff, mentioned the offensive weapons required by the United States and called for modernization of the air transport fleet by conversion to turbofan engines. The troubles in Iraq, Jordan and the Lebanon in 1958, and in Laos in 1959, had shown that the need for a highly mobile "fire brigade" was imperative. For obvious political reasons, Allied or American forces cannot be deployed over the entire face of the globe; yet we must be capable of responding to the appeal of a government in peril by timely action against any aggressor. The advocates of the B-70 *Valkyrie* have intimated that this bomber, suitably converted, could carry armed GIs from California to Laos in a matter of hours, and that the rapid movement of troops to any point on the globe may well be as important as the ability to carry out bombing missions. Backing up General White, Lieut.-General William H. Turner, Commander of the Military Air Transport Service, demands:

- transport aircraft directly derived from the Boeing 707, Douglas DC-8 or Convair 880, travelling as fast as the civil versions and capable of transporting men and arms;
- turbine aircraft to replace the present piston-engined Douglas C-124s, and heavy transports for ballistic missiles, such as a fleet of Douglas C-133s.

Naturally, in the more distant future, military transport operators will be ready to join hands with their civil colleagues. The Air Force must foot the bill for research and experiments on a Mach 3 bomber from which the civilians will derive a commercial airliner and the military, in its turn, a fast transport. With such miniaturized atomic weapons as the *Davy Crockett* in existence, a Mach 3 transport could carry a formidable quantity of destruction to the other side of the world in a few hours. Based on such foundations, the policy of "showing the flag" could be remarkably intimidating.

Thus, with nuclear explosives in all their forms, short take-off combat aircraft, highly mobile ballistic missiles, fast transport aircraft carrying miniaturized atomic weapons, a wide field of activity lies open, both to those who design and build this new arsenal for peace and to those who put it into operation. ◆◆

On October 13th, 1959, this Martin long-range experimental rocket was fired from a Boeing B-47 jet bomber over Cape Canaveral to the immediate vicinity of the *Explorer VI (Paddlewheel)* satellite. This experiment shows that large-calibre rockets can be launched from aircraft against both surface targets and enemy missiles. This greatly increases the mobility of offensive and defensive weapons.



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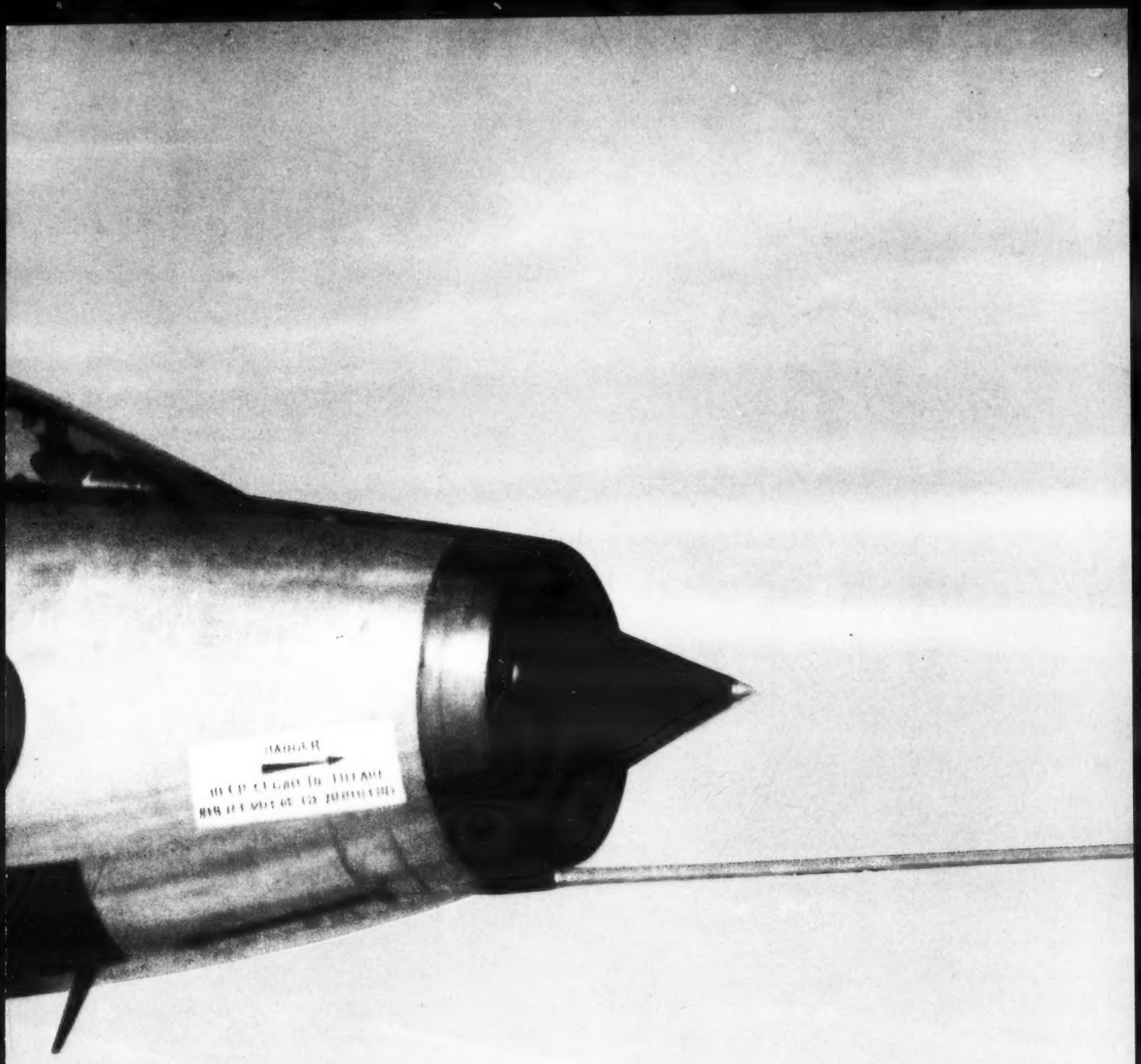

'ENGLISH ELECTRIC' *Lightning*

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What NATO needs — th

WIDE SPEED RANGE

Designed to give high-level supersonic performance as a fully integrated weapon system, the Lightning has a top speed in excess of Mach 2 yet is completely controllable over a speed range greater than thirteen to one. It loses none of its outstanding flying characteristics in subsonic or transonic flight.

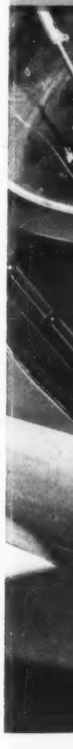
ALL-WEATHER OPERATION

The Lightning has been designed as an all-weather day or night interceptor. Its comprehensive instrumentation, versatility and superb flying qualities enable it to fulfil its role safely and efficiently under all climatic conditions.

OUTSTANDING PERFORMANCE

The Lightning reaches a speed of Mach 0.9 in level flight at operational height within 2.5 minutes from brake release. In considerably less than 3.5 minutes it can accelerate from the speed of sound to Mach 2.

At all altitudes the Lightning is highly manoeuvrable and fully aerobatic whether subsonic or supersonic; such outstanding performance makes the aircraft suitable for a number of roles including Ground Attack and Photo-reconnaissance.



the "Lightning" has .... *Now*

TWIN ENGINES FOR RELIABILITY AND ECONOMY ... Two engines to provide reliability are a vital requirement in a supersonic fighter aircraft.

An added safety factor in the case of the Lightning is the positioning of both engines along the centre-line of the fuselage so that the aircraft does not develop asymmetric characteristics when flying on one engine.

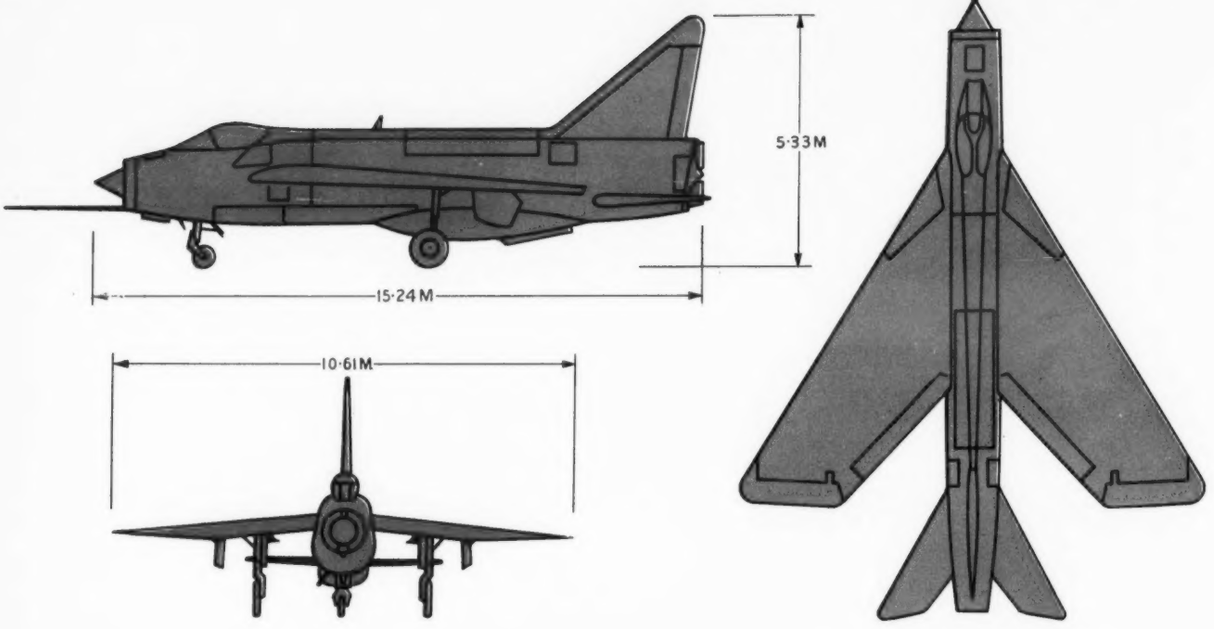
Further reliability on the Lightning is provided by complete duplication of all power control systems and their associated power supplies.

The two Rolls-Royce Avon engines provide supersonic performance without re-heat and afford great fuel economy under appropriate conditions.

Two-seat version now available

The two-seat version of the Lightning now available has all the outstanding qualities of the single seat version and a comparable performance. It can be used as a trainer, for conversion purposes, or as an operational aircraft... or this same aircraft can fulfil all these functions.

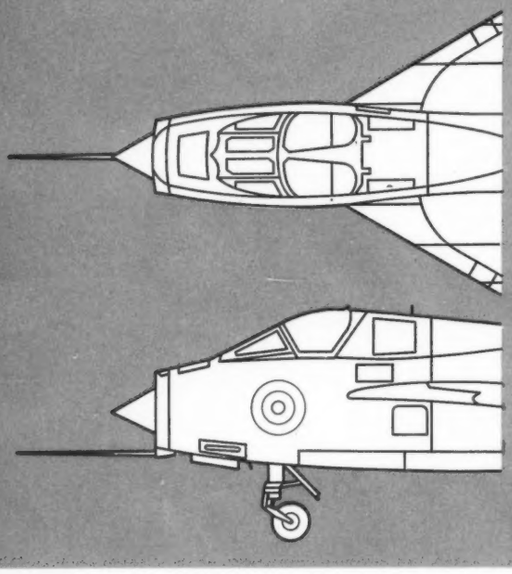
In its operational role the pilot can give full attention to



his instruments while the radar operator takes over fire control responsibilities.

The two-seat Lightning is equipped with the same full navigational and landing aids, airborne search and track radar as are fitted to the single seat version.

All controls and instruments including Radar Fire Control are duplicated.



AN INTEGRATED WEAPON SYSTEM

The engines, airframe, radar equipment, the electronic aids, the armament, the fire control devices—all were planned from the start to work as a coordinated whole to achieve maximum operational performance.
A variety of armaments can be fitted to meet different operational requirements—all are developed within this integrated weapons concept.

INHERENT AERODYNAMIC STABILITY

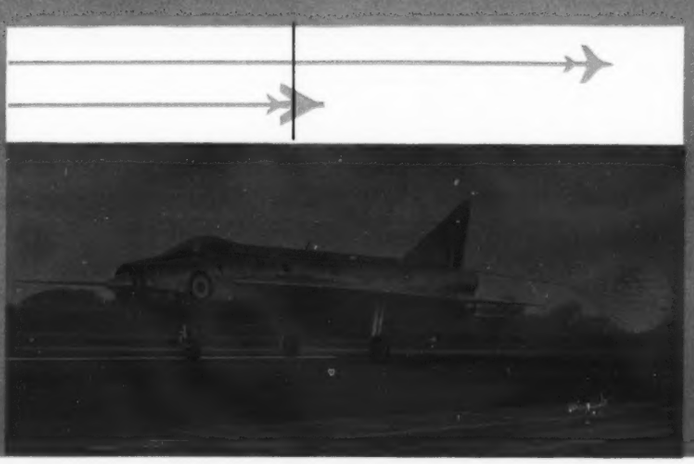
Ease of control at all speeds is achieved without autostabilisation; the Lightning does not depend upon electronically supplied stability. Autostabilisation is there—but needed only as a refinement in the tracking, and attack phases.
All this has been achieved because the design of the aircraft is such that it is inherently aerodynamically stable and completely free from pitch-up throughout its entire performance range.

DEVELOPMENT POTENTIAL

The Lightning is only at the start of its great potential. This basic design offers great possibilities not only for increased performance but also for adaptation to other roles. This potential ensures great economies in operation.

EASE OF LANDING

No complicated landing techniques need be learned nor any extensive runway alterations made, for the Lightning can be landed and brought to rest in 800 yards.



English Electric Aviation Limited Marconi House, Strand, London WC2

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Space Research is a Sound Investment

By Professor Dr. J. Ackeret, Federal Institute of Technology, Zurich

Somewhere in Hermann Oberth's work "Wege zur Raum-Schiffahrt," which appeared 30 years ago, are the words: "For preliminary testing (of a rocket to carry mail from Europe to America) I should certainly not need as much as 10,000 marks." This is perhaps the only miscalculation in a book containing a wealth of interesting ideas which have since proved feasible and of fundamental importance. But how differently the author's ideas on finance have turned out! The development of long-range rockets and space probes swallows up vast sums of money, even when it is purely a question of "preliminary testing." Many people will wonder whether such efforts are of any real value to a country's economy. The answer is an unreserved yes: *quite apart from political considerations, space travel is becoming a* means of research of incalculable importance. *Although today we are still battling with countless technical difficulties, the scientific harvest is already rich and holds promise of many new discoveries to come. There are, basically, three main groups of problems to which space travel can furnish at least some of the answers:*

- *the origin of the solar system,*
- *cosmology (the origin, structure and end (?) of the universe),*
- *the origin of life.*

Alongside these, however, an independent technology is developing (new materials, methods of propulsion, instruments etc.), which cannot fail to be of major significance for more conventional engineering problems.

The objective is clear, youth is straining at the leash, there can be no turning back!

J. Ackeret

Exploring Space – The Immediate Goals

Any slogan which might divert the twentieth century from the armaments race is wholeheartedly welcome. "Space travel is essential," proclaim the most technically advanced nations of the world, convinced that their bid for the stars will bring the whole of mankind a step further forward. It might, however, be asked whether the more modest slogan "Space *research* is essential," might not serve the interests of progress better.

What is space research? The theoretical and experimental investigation of objects and phenomena both within and beyond the upper layers of the earth's atmosphere, based on direct or indirect measurements by rocket probes, artificial satellites, space laboratories and earth-based support equipment. This was roughly the definition given in a report submitted to the Ninth General Assembly of AGARD by the U.S. National Aeronautics and Space Administration. Though space research draws on experience gained in physics, chemistry and biomedicine, it is based primarily on the disciplines of astronomy, astrophysics and geophysics. The atmospheres and ionospheres of the earth and other planets, their electric, magnetic and gravitational fields, the sun, energetic particles, plasmas, electromagnetic radiations and the search for extra-terrestrial life – whatever the fields of activity for space research, they will help to answer an age-old question: How did our universe come into being and how is it composed?

Neither this question nor space research is a novelty. Both are, properly speaking, as old as astronomy, and both are linked with the most illustrious names in natural science: Hipparchus, Ptolemy, Copernicus, Galileo, Kepler, Newton and Einstein. A new era began, however, with the introduction of space *travel,* which enables scientists to send their research instruments far out into the universe, instead of relying on the few rays of light which succeed in penetrating the layers of the earth's atmosphere. It is true that many years ago radio-astronomy revealed the presence of distant sources of cosmic radiation which the telescope could not detect; and after World War II systematic high-altitude research began using rockets whose instruments gathered new secrets from the sun and the ionosphere. But not until the International Geophysical Year, 1957–1958, did the world's two leading powers speed up their technical programmes and take the decisive step into space, starting out overnight on that adventure which has been man's dream for thousands of years.

Full-size model of a giant rocket motor with 500 to 1,000 tons thrust, projected by Aerojet-General. At the top of the model, which is set up in the company's Sacramento plant, can be seen the fuel pumps and a gimbal mounting.

Artificial satellites – circling the earth in minutes or hours and covering a large portion of the space surrounding our planet – provide a far more extensive basis for research than rocket probes, which leave the earth's atmosphere for only a few minutes at a time. As a result of the information collected by the artificial satellites it was possible to plan new, far-reaching research programmes in which the planets of the solar system and the space between them play a decisive role. In the meantime the network of satellite tracking and receiver stations spread across the face of the globe was improved and extended. More accurate booster guidance systems, refined measuring instruments in satellites or space probes, new attitude control devices to orientate the measuring equipment in space, and transmitters with higher performance, have enabled mechanisms devised by man to penetrate farther and farther into the solar system and transmit their information back to earth without the aid of a human operator. The first human beings ever to be entrusted to these space laboratories will confine themselves to direct observation of the environmental conditions which will confront later generations of astronauts in their expeditions into interplanetary space. Of course, the scientist himself will one day want to be in his laboratory as it hurtles through space, but for the time being – and the NASA programme for years ahead makes this quite clear – he must, as it were, bring space down to earth. In this he is helped by rockets and artificial satellites or planets carrying the most advanced instrumentation.

Current results

No scientist today could seriously assert that our knowledge is adequate to plan all the phases of, say, a manned trip to the moon with a high enough degree of safety for all travellers. We can only venture step by step into the perilous zone

between the earth and its natural satellite. Even the experiments with unmanned satellites and space probes have gone forward gropingly. This should be remembered when we consider the results so far achieved in American and Russian space research; it also explains why despite rapid progress in rocketry, space research will be slow in yielding comprehensive results. The countless attempts to probe the belts of radiation around the earth are a typical example.

The aims of future programmes will be better understood by taking a retrospective glance at the beginnings of space research, following NASA's classification of the subject in six main categories:

The atmosphere: Once Torricelli had invented the mercury barometer in 1643 and Mariotte and Huygens discovered the laws governing the distribution of pressure with altitude at the end of the 17th century, physicists gradually succeeded in gaining a knowledge of the atmosphere up to about 20 miles—even though their assumptions as to molecular weights and temperatures did not quite tally with the facts. Though certain notions regarding the atmosphere above 20 miles were gained at the beginning of the twentieth century from studies of meteors and auroras and radio-wave ionospheric measurements, it was not until 1946 that systematic measurements with rocket probes enabled more precise conclusions to be drawn regarding the atmosphere at heights of 60 miles and above. These results enabled a so-called standard atmosphere to be reconstructed in 1952 for altitudes between 0 and 50 miles. As a result of rocket launchings in the International Geophysical Year, the ceiling of the standard atmosphere was raised to about 125 miles, and even as high as 300 miles for certain physical values.—Of decisive importance, however, were the satellite measurements taken at heights between 110 and 450 miles; these furnished not only information on the density for the upper layers of the earth's atmosphere, but also new data on atmospheric temperature structure. Thus, for example, considerable fluctuations in density and temperature were noted at altitudes over 125 miles, fluctuations which apparently depended both on the time of day and on the position at which the measurement was made.

The ionosphere: The growth of radio at the beginning of the twentieth century led to the discovery of the earth's ionosphere, that variable region of the atmosphere which reflects radio waves as a result of the high degree of ionization of its particles. The first step was to find the electron density in the so-called D, E and F layers of the ionosphere and to obtain information on the daily, seasonal and geographical variations in the height and characteristics of each layer. With the aid of rockets and electronic computers an electron density profile was determined up to a height of about 200 miles, and the little so far known of the region between 160 and 320 miles was increased. Although satellites enable electron densities to be measured at considerably higher altitudes, measurements are still relatively difficult to evaluate, as no reliable horizontal density profile is yet available. Horizontal fluctuations depending on latitude, and other irregularities in the horizontal density structure, introduce errors into the measurements.

Energetic particles: The discovery of energetic cosmic radiation just before World War I set scientists many puzzles which were only partially solved by the balloon ascents after World War II. It was then established that this radiation consists of protons, alpha particles and heavy atomic nuclei and that its energy can be as great as 109 Bev.[1] But the riddle of these particles' origin and the mechanism by which they reach such powerful energies, remained unsolved. Rocket measurements confirmed the results of earlier balloon ascents, but not until the satellite launchings was new light shed on the mystery of this natural phenomenon. The Soviet Sputnik III met by chance with a swarm of auroral electrons and took the first measurements of their energy and density—although these measurements were limited by the range of the instruments aboard the satellite. American satellites made the unexpected discovery of the so-called Van Allen radiation belts—accumulations of charged particles of varying energy—which are trapped in the earth's magnetic field as in a cage. Now that plausible theories as to the origin of these belts have been put forward, special probes are being prepared to seek out accumulations of radiation around other planets.

Electric and magnetic fields: The manifestations of atmospheric electricity in the form of lightning have been adequately investigated by rocket probes and are expected to be of purely secondary interest in future space research. On the contrary the earth's magnetic field, changing from day to day and slowly shifting with the passing of the centuries, presents a number of riddles. As measurements taken from the earth can never yield complete, i.e. three-dimensional results, our notions of the earth's magnetic field must be corrected by using space vehicles.

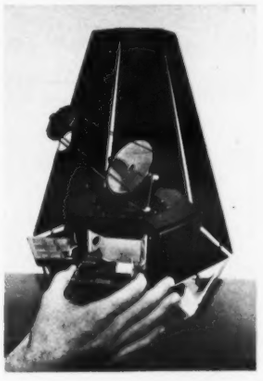
Gravitational fields: The best current explanation of the nature of gravitation is to be found in Einstein's general theory of relativity, which is, however, far from being entirely satisfactory. It does not explain, for instance, whether or not gravitation has a "velocity of propagation" in the same way as light. Furthermore, no relationship has yet been established between the theory of the gravitational field and that of the electromagnetic field. Experiments on an astronomical scale would be necessary to prove certain consequences of the theory of relativity and discover the missing links in the chain of natural law.—Rockets alone would hardly suffice to detect anomalies in the earth's gravitational field; artificial satellites, however, are highly suitable as research vehicles. Their orbital periods are so short that, for instance, disturbances in the gravitational fields existing between two celestial bodies, which would formerly have required centuries to detect, can be revealed within months or even weeks. Thus the orbit of *Vanguard I* (1958 Beta) indicated that our concept of the earth as a spheroid equally flattened at both poles and bulging at the equator must be slightly modified. The earth is, in fact, slightly pear-shaped, the stem of the pear being in the northern hemisphere. *Vanguard I's* orbital data also indicated that the bulge around the earth's equator is about 500 feet thicker than had been believed. The existence of this larger diameter cannot so far be reconciled with the "hydrostatic equilibrium" concept, according to which the earth's mantle is flexible and bulges under the influence of rotation.

Cutaway model of a 6,000 lb rocket engine developed by the Jet Propulsion Laboratory for the third stage of the *Vega* space vehicle. The propellants (nitrogen tetroxide and hydrazine) can be stored for weeks in their spherical containers (not shown here).

Last-minute adjustments to an American lunar probe at the Jet Propulsion Laboratory. This 91.5 lb payload was later mounted on the final stage of a four-stage *Juno II* booster and launched towards the moon from Cape Canaveral.

Right: This one-sixth scale model of the *Vega* Mars instrument package shows a hexagonal instrument container, two of whose panels are opened to show electronic assemblies. On top of the container is the infra-red spectrophotometer with collector plate, which is designed to tilt and rotate so as to be continuously pointing at Mars while the payload is in orbit. Energy is supplied by six unfolding solar converters (not shown here). The entire payload has been designed by the Jet Propulsion Laboratory.

Far right: This gyro-stabilized platform, which is part of the inertial guidance system of Project *Vega*, contains three accelerometers and three gyroscopes. The small cutaway model at bottom left is an accelerometer, that at the right a gyroscope.



[1] 1 Bev = 1,000 million electron volts.

Astronomy: Of special interest are astronomical observations from space platforms, which began about ten years ago with rocket experiments. This branch of research was discussed in detail in the May, 1959, issue of *Interavia* Review (p. 536 et seq.). Whereas earth-based instruments could not probe the portion of the solar spectrum below a wavelength of 3,900 Angstrom[2], rocket or satellite experiments have made it possible to record the whole wave scale down to 1 Angstrom. Spectacular results were obtained from photographs of the sun in the light of the Lyman alpha line of hydrogen (1,216 Å) and photographs of the heavens in the far ultra-violet region, which led to the discovery of nebulae hitherto unknown. — Satellites have recorded micrometeorite density at the edge of the earth's atmosphere and in space. Their measurements show that 10,000 tons of cosmic matter fall to earth every day. Furthermore, a correlation was established between meteor showers and rain precipitation, and it was proved that the ionosphere is produced primarily by solar ultra-violet rays and occasional solar X-ray radiation.

To study the behaviour of space vehicles on re-entry into the earth's atmosphere, models are fired from a helium gun (far right) along this gas-filled steel tunnel, their flight being recorded by high-speed cameras and X-ray equipment. The installation is at the Langley Research Center.

Aids to research

Equipment used in space research ranges from rockets, satellites and guided space probes to the wide variety of ground installations required for launching carrier vehicles, tracking probes, receiving signals and evaluating data. Boosters present the thorniest and costliest problem. The most essential piece of equipment for the success of any experiment, they have undoubtedly caused space planners more headaches than any other part of their projects. The latter part of this article will therefore return to the subject of boosters. Here it should merely be recalled that the characteristics of a rocket, such as acceleration at take-off, level of vibration, accuracy of trajectory etc., affect the design and layout of the scientific instruments it carries.

The trajectories along which space vehicles travel in any given gravitational system are ellipses, parabolas or hyperbolas—unless they are altered by external forces. The intended launching or release velocity must, of course, be maintained with the greatest accuracy, or the vehicle will deviate from the desired path.

In the case of an exactly circular orbit around the earth this velocity depends purely on the height of the orbit, as is shown by the following table:

Height in miles	Velocity in m.p.h.	Approximate period	Probable life
200	17,580	90 min	Days to months
300	17,420	93 min	Years
500	16,960	100 min	Decades
1,000	15,700	2 h	Centuries
22,000	6,800	1 day	Millennia

Of special interest is the last-mentioned orbit where a satellite launched due eastwards above the equator into a circular orbit of 22,000 miles' height will appear to be stationary in the sky. Even if such a satellite were not launched due eastwards, but slightly north or south of east, it would still remain above its initial meridian, but would appear to the observer to deviate alternately to the north and south of the equator. In addition, a satellite near to the earth can, if launched westwards at an angle of 83° to the equator, be directed onto a transpolar orbit, where it will remain constantly in the twilight zone of the earth as it rotates about the sun. Its orbital plane will precess to the east at the same angular velocity as the plane of the earth's twilight zone. Such an orbit would have great advantages for, say, military observation satellites with infra-red detectors.

Far more difficult are the problems of calculating and maintaining the trajectories of deep space probes. These, too, are in the form of elongated ellipses, parabolas or hyperbolas with the earth's centre as one of their foci; but as soon as a probe leaves the earth's gravitational field, it comes under the influence of a number of other factors, the chief of which is the sun's force of attraction. The probe would then normally go into an elliptical orbit around the sun. If, however, its total impulse is so powerful that it passes the sun on a hyperbolic trajectory, it will finally penetrate into another solar system. One day it should be possible to develop rocket propulsion systems with such high total impulse, though it is doubtful whether there will ever be communications equipment capable of transmitting or receiving signals over interstellar distances.

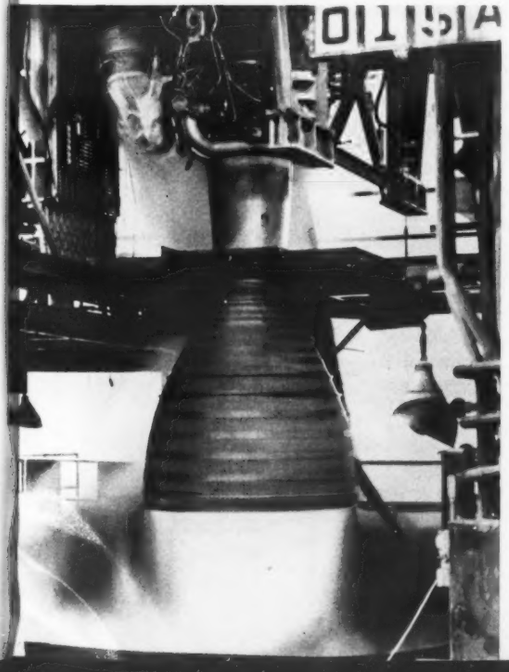
Tracking and data reception, even of satellites, requires a far-reaching network of expensive ground installations, of whose number and cost the layman can have no idea—not to mention the launching apparatus for boosters weighing hundreds of tons. The American Minitrack network alone comprises a dozen radio stations with special receivers throughout the world; five further stations are planned for North America, Alaska and Spain. The Smithsonian Astrophysical Observatory maintains twelve optical observation stations equipped with Baker-Nunn satellite cameras in North and South America, South Africa, Europe, Asia and Australia. The Microlock data transmission system consists of a fur-

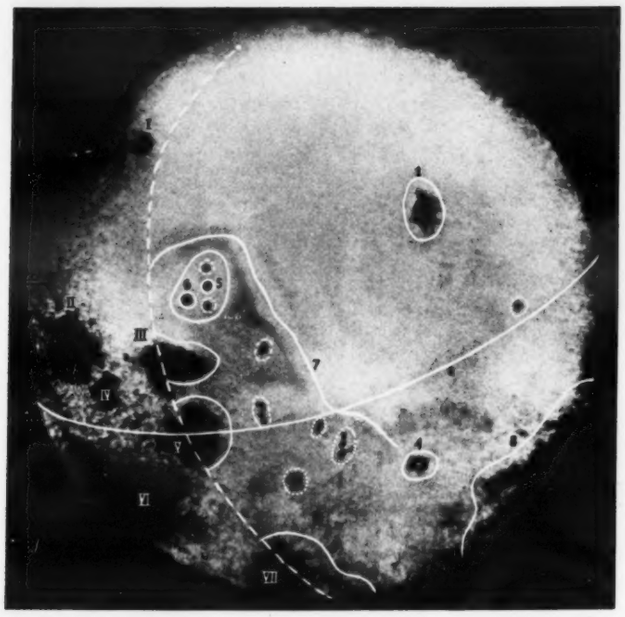
A model of a proposed re-entry vehicle being tested in the supersonic pressure tunnel at NASA's Langley Research Center. The vehicle is designed to return to the earth's atmosphere at hypersonic speed at an angle of nearly 90°, with wing-tip panels folded vertically. As the vehicle reaches subsonic speed the panels are extended horizontally.

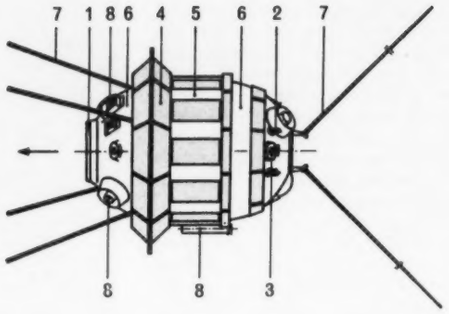
Scientists at NASA's Langley Research Center experiment with a plasma accelerator and record the test with a sequence camera with a high-speed shutter.

[2] 1 Angstrom = 10^{-8} cm.

First picture of the test run of a Rocketdyne E-1 engine in the 400,000 lb thrust class. The turbo-pump of this mighty powerplant was developed from the feed system of the since abandoned *Navaho* booster.







The Soviet space probe *Lunik III*, launched at the beginning of October, 1959 (see drawing above), circled the moon at a distance of about 4,700 miles on October 6th and took several photographs of the back of the earth's natural satellite. After evaluating the radio information transmitted to the earth, the Soviet Academy of Sciences published a "reconstructed" picture of the reverse side of the moon, whose features were given Soviet names. The dotted curve running from top to bottom of the picture marks the limit between the face of the moon which is turned to the earth (left) and the part so far unknown. The Roman figures mark features visible from the earth, Arabic figures the new features (ringed), which include: 1 – Sea of Moscow; 4 – crater with Tsiolkovsky peak; 5 – crater with Lomonossov peak.

Key to drawing of *Lunik III:* 1 – camera window; 2 – attitude control nozzles for orientation system; 3 – solar converter; 4 – sections of solar battery; 5 – heat regulation system louvres; 6 – heat shield; 7 – antennas; 8 – scientific instrumentation.

ther dozen stations with doppler receivers. In addition, there are five powerful radio telescopes in America, Britain, and Hawaii; six more stations are planned in Australia, South Africa, Spain, Japan, Bermuda and the South Pacific.

Future Plans and Projects

The International Geophysical Year left behind it a rich heritage. Not only the USA and the Soviet Union, but also Australia, Great Britain, Canada, France and Japan entered the field with their own rocket research programmes. The United Nations created an *ad hoc* Committee on the Peaceful Uses of Outer Space, and even the International Council of Scientific Unions founded a special Committee on Space Research (COSPAR).

In the USA NASA was founded, coordination of separate defence branch programmes immediately began, and, as was only to be expected, new projects were drawn up. The following are some details of NASA's formidable overall programme for the near future. Under an atmospheric research project several cloud observation satellites are to be launched to investigate the structure and dynamics of the upper atmosphere. The purpose of these experiments is not only to obtain a better interpretation of the various phenomena occurring in the upper layers of the atmosphere, but also to lay the foundations for atmospheric studies of other planets. To study cosmic radiation and obtain more precise information on the nature and intensity of heavy particles, photographic plates will be sent into space and returned to the earth in recoverable capsules. A geodetic survey satellite is in preparation for more accurate measurements of the earth's gravitational field and for checking the distances between continents. Furthermore, there are plans for putting into orbit a satellite carrying a high-precision atomic clock to test Einstein's general theory of relativity with respect to the earth's gravitational field. It is also planned to launch special satellites and rockets carrying cameras to take pictures of space in the ultraviolet region (stellar photometry).

The various tasks of American space research have been grouped by NASA under several main programmes among which the $501 million allocated to the Administration for 1959–1960 will be distributed as follows:

1 – Manned space flight (preparations for Project *Mercury*) Approx. 15%

2 – Scientific exploration of the upper atmosphere and outer space (including weather observation and communications satellites) approx. 15%

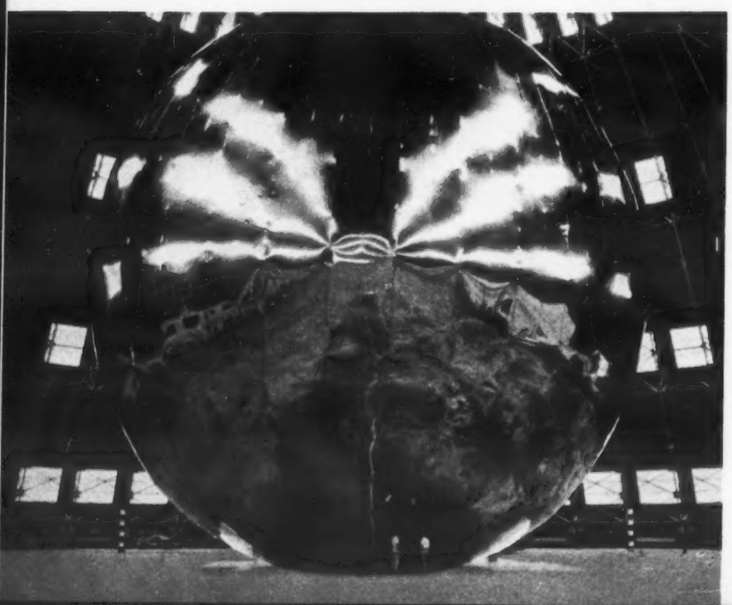
3 – Space vehicle programme approx. 25%

4 – Special funds for research and development programmes undertaken by NASA or its subcontractors over 25%

5 – Upkeep of NASA research facilities and a world-wide tracking and data-acquisition network 18—20%

NASA's complete programme for July, 1959, to December, 1960, makes provision for the following experiments:

Programme	Instrument carriers		
	Rockets	Satellites	Probes
Atmospheres	53	2	3
Ionospheres	4	2	2
Energetic particles	11	3	5
Electric and magnetic fields	32	3	5
Astronomy	20	3	3
	120	13	18



◀ This NASA gas-inflated radio reflector satellite consists of a very thin plastic film coated with aluminium, weighs about 65 lb and can be folded into a container the size of a pumpkin.

▶ Re-entry vehicles in new shapes are continually being tested at the Langley Research Center. The picture shows a wedge-shaped space glider with circular sections as stabilization fins and wings. When the vehicle is released in space, the latter are folded together to form a cone with a cylindrical base and, on re-entry into the atmopshere, spring open to form a pair of Ws, as shown here.

New materials and designs

The construction of both carrier vehicles and space probes requires extensive research into materials and design and the solution of completely new technical problems. Among these has been the development of a radio reflector satellite in the form of a 65 lb folding balloon made from Mylar fibre with an aluminium skin; when inflated, the satellite will have a diameter of 100 ft, but will fold into a container the size of a pumpkin.—Particular difficulties are involved in designing space vehicles which will re-enter the atmosphere and return to earth unharmed after their mission is complete. Not only do the high temperatures encountered (over 1,600°C at leading edges), make heat-proof metal shields or even ablative leading edges imperative; they also involve the use of elastic internal structures which expand or contract like a concertina under the effect of heat on the skin. A later report will deal with NASA's interesting research into heat-absorbent shields, insulated skin panels, sliding expansion joints, ablative noses and leading edges and light inflatable structures.

... and magnetoplasmadynamics

It is essential to bring not only manned vehicles back to earth, but also those carrying research equipment for biomedical experiments, gas sampling, the recovery of data stores etc. The military requirement for carrying nuclear warheads over intercontinental distances through space has meant a ten-year study of the so-called re-entry problem involving questions of aerothermodynamics and the stability and strength of vehicles penetrating the earth's atmosphere at hypersonic speed after a long journey through space. However, the solutions which are acceptable for ICBM warheads are not necessarily so for vehicles returning from Mars or for manned space stations. — As magnetic phenomena, ionized (i.e. electrically conductive) gases and gas movements affect the re-entry process to a considerable degree, the research concerned was given the significant name of *magnetoplasmadynamics*. Magnetoplasmadynamics, or MPD, not only deals with the problems of vehicle re-entry into the earth's atmosphere, but also gives plausible explanations for the newly discovered belt of radiation around the earth. In addition, it provides the basis for all thermonuclear fusion processes and is at the same time the key to projected "electrical" propulsion systems (extraction of energy from a moving plasma etc.).

Research institutes and industrial concerns have already been experimenting for years with plasma generators producing gases at temperatures above 5,000°C in laboratories on the earth. The four main potential sources of energy for space vehicles—solar radiation, radioactive isotope decay, nuclear fission and thermonuclear fusion—can only be used if the available quantities of energy can be converted to thrust or torque in accordance with the principles of magnetoplasmadynamics.

American boosters of the next decade

Interavia Review has already published several reports on the U.S. space programme (cf. No. 6, 1959, p. 738 et seq., and earlier articles); the present article will therefore confine itself to a brief summary of the most important American boosters (nothing is known of Soviet developments). The NASA programme provides for four categories of vehicle: cheap, easy-to-handle multipurpose boosters for small payloads, such as the Chance Vought *Scout*; boosters based on the *Thor* and *Jupiter* IRBMs, such as *Juno II*, *Thor-Able* and *Thor-Hustler*; boosters for large payloads based on the *Atlas* ICBM, such as *Centaur*; and finally, giant rockets such as *Saturn* and *Nova*.

Work on the three-stage *Centaur* booster is going ahead at full speed in the current fiscal year. *Centaur* will have a Pratt & Whitney lox/liquid hydrogen second stage and a Jet Propulsion Laboratory storable liquid-propellant engine as third stage, as also planned for the now-cancelled *Vega* vehicle. The two propellants used—nitrogen tetroxide and hydrazine—can be stored for weeks in their integral containers. JPL has recently published a sectional picture of its rocket engine. The combustion chamber and nozzle consist of

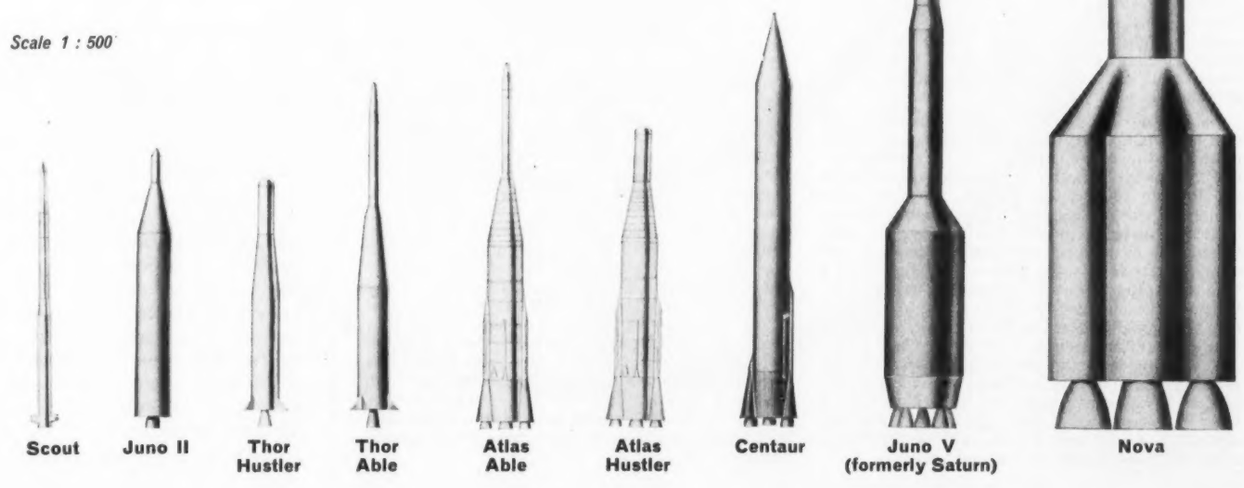
These scale drawings of nine American boosters for satellites and space probes represent a cross-section of the NASA procurement programme for the coming years and at the same time give an impression of the size of the most important rockets. The smallest, the *Scout*, is about 70 ft long, the *Nova*, the largest so far under development, almost 300 ft. The tables show the planned applications of these space rockets.

Table I: Instrument Payloads for Lunar Exploration

Mission	Vehicle	Payload weight in lb
Near miss	Juno II	15
Impact	Thor-Delta	100
Unmanned orbiters	Thor-Delta Atlas-Hustler	65 250
Rough landings	Thor-Delta	50
Soft landings	Atlas-Centaur Juno V Nova	730 1,700 19,900
Unmanned orbit and instrument return	Atlas-Centaur Juno V	275 700
Soft landing of instruments and sample return	Juno V	200
Manned landing and return	Nova	2,100

Table II: Instrument Payloads for Interplanetary Probes

Mission	Vehicle	Payload weight in lb
Space probes (Initial interplanetary)	Thor-Able Atlas-Able	50 200
Venus and Mars near miss	Atlas-Hustler	200
Venus and Mars orbiters	Juno V Nova	900 15,000
Venus and Mars atmosphere entry	Centaur	1,300
Solar probe and Jupiter near miss	Juno V	1,900
Venus and Mars landing	Juno V Nova	400 4,500



Atomic reactors as powerplants for space vehicles

The possibility of transmitting the thermal energy produced by nuclear fission via a heat exchanger to a fluid which, in its turn, will drive turbo-generators or pumps, was recognized shortly after the first atomic reactors were invented. But reactors, anti-radiation shields and reactor cores were far too heavy and unwieldy to be fitted to rockets. The U.S. Atomic Energy Commission, in collaboration with North American Aviation, has recently developed a miniaturized atomic reactor for use as a satellite or rocket powerplant.

The prototype reactor designated SNAP (Systems for Nuclear Auxiliary Power) II, weighs 220 lb without shielding, measures 18×14 in. and has a power of 3 kW. Its core consists of 61 fuel elements containing 6.6 lb of fully-enriched uranium embedded in zirconium hydride for moderating purposes. The reactor coolant is liquid sodium, which delivers its heat to mercury in a heat exchanger. The vaporized mercury drives the turbogenerator and pumps at 40,000 r.p.m.

The SNAP II reactor was designed by Atomics International Division of North American Aviation, while Thompson-Ramo Wooldridge built the turbo machinery. The latter has a weight of only 25 lb and an estimated life of one year. According to AEC scientists, SNAP II will be relatively safe for ground teams on the launching pad, as it need not be activated until it is established in orbit or a space trajectory. On the other hand, the Martin Company's SNAP III

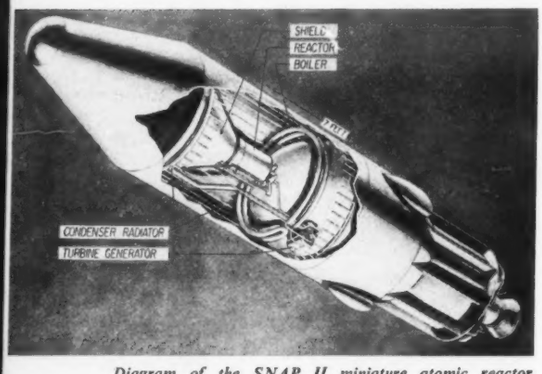


Diagram of the SNAP II miniature atomic reactor built by the Atomics International Division of North American. Here the reactor and turbo-generator are seen installed in a Discoverer *satellite.*

experimental miniature reactor announced about a year ago must operate full blast before firing and therefore presents a greater radiation hazard to the launching pad and its surroundings in the event of a rocket malfunction. The Martin reactor uses radioactive polonium 210 as a heat source and thermoelectric materials to convert the heat to about 5 watts of electricity.

NASA and the Atomic Energy Commission are also working together on a high-temperature nuclear reactor and auxiliary hardware for the construction of a nuclear space rocket. It is expected that in about five to eight years a unit may be ready for flight testing in giant rockets such as the *Nova*.—Various elements are being developed separately, the AEC having the most important piece of research and development, namely the *Kiwi-A* reactor. This is a high-temperature reactor moderated by graphite, which transfers its heat directly to a blast of hydrogen flowing through its centre. The *Kiwi-A* has already been tested at the Jackass Flats facility in Nevada, and is being used for the study of heat transfer problems resulting from operating graphite moderators at high temperatures, and for testing various fuels. At a later phase of the programme new reactors, designated *Kiwi-B* and *Kiwi-C*, will be developed, using pump-fed liquids to transmit energy.

In collaboration with North American's Rocketdyne Division, AEC and NASA have developed a liquid-hydrogen pump (Project *Rover*) to be used with the *Kiwi* reactors. The first nuclear powerplant set up is expected to use the pressure-feed system, blasting gaseous hydrogen (evaporated from liquid) through a reactor. When the pump has been completed, the hydrogen will be pumped through the reactor, thus overcoming the high internal pressure, which may be almost 1,000 p.s.i.

One of the most important problems of the project will be the development of flow controls, such as valves, switches etc., which will withstand radiation and high temperature (temperatures inside the reactor are expected to be around 2,200°C). Several firms, including Thompson-Ramo Wooldridge, have already been awarded development contracts. The Air Research and Development Command has also awarded contracts for research into the effects of nuclear radiation on structural materials and the development of seals. Lockheed Aircraft Corporation has received a contract to study the effect of radiation on very cold materials at liquid hydrogen temperatures (around —253°C). Investigations so far made have shown that radiation damage to metals and liquid gases is far more severe (and hence more dangerous) at low temperatures than at ordinary temperatures.

One of the most important new developments in the field of antiradiation protection, particularly for manned space vehicles, is the concept of "sandwich" shielding; this consists of several layers of boron and beryllium interspersed with plastic foam. As the radiation passes through one metal shield, it will generate secondary "showers" of nuclear particles which, in turn, will be absorbed by the "sandwiched" plastic foam layer; the heavier particles will, of course, continue to the next shield, but will by then have been considerably slowed down. It is hoped that this principle may solve the difficult shielding problems for space vehicles, though it has been estimated that shielding will account for at least one third of the total weight of the nuclear system (5 to 10 tons).

The ultimate reactor and nuclear engine will work on the principle of direct heat transfer from the reactor to the hydrogen, although secondary indirect heat transfer systems using liquid metals have also been proposed. As boiling metals are weightless in space, it will be necessary to test the effect of the weightless condition on conductive heat transfer and the boiling of metals.—The first nuclear test in space will most likely be performed with chemical boosters, and the nuclear reactor will not begin to function until it has been fired into space. Already, however, laboratories and universities are conducting research into the reactor's fate after it has completed its experiment. The question is: How will accumulated heat be dispersed after shutdown when there is no more liquid to cool the reactor ?

It is expected that the *Kiwi* reactors will ultimately work up to power levels of 1,000 kW, but initially, due to the problems of the materials used, levels will be far lower. A few of the problems facing scientists and engineers are as follows: "poisoning" of the fuel elements in the reactor; melting of the moderator at high temperature; erosion of the graphite moderator rods by the hot hydrogen flow in the reactor; the effects of cosmic radiation on the reactor's operation (external "poisoning" of the fuel elements) and on the reactor materials. Various materials other than graphite have been proposed for reactor moderators, such as molybdenum carbide, zirconium carbide, tungsten carbide, etc., and methods of keeping the uranium fuel intact under the influence of high temperatures are also being studied. But years of detailed research will still be necessary before nuclear rockets become a practical reality. The primary task is the fitting of the unit into a multi-ton satellite, which may be done by NASA itself; this in turn will require enormous boosters. But with a possible specific impulse of 1,000 to 2,000 sec, and with hydrogen as a working fluid, the attractions of a nuclear rocket are so great that the *Kiwi* programme and other AEC projects, still secret, will be pushed ahead at full pressure.

seamless drawn stainless steel tubes which can be adapted to fit the engine by altering their cross-section. The propellant is pumped through the tubes to regeneratively cool the chamber. When the propellant and oxidizer meet, they ignite spontaneously (hypergolic combination). A helium system is used to feed the propellants into the combustion chamber.

The uncomplicated propellant feed system and the integral tanks, which require no maintenance and which are in continual operational readiness, make the *Centaur* third stage engine a simple and reliable powerplant, even at high altitudes. It is also the first to use a combination of nitrogen tetroxide and hydrazine as propellants.

The *Centaur* rocket will be able to carry an instrument payload (and, if necessary, its own final stage) to a "parking orbit" on which the vehicle will circle the earth until the most favourable conditions are at hand for longer trips to the planets.

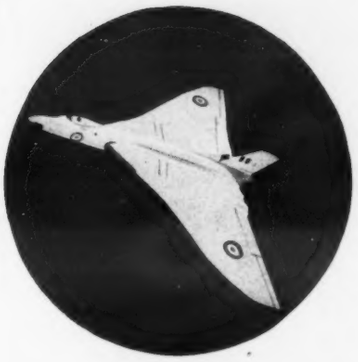
In the meantime chemists are continually seeking new propellant combinations which will enable more energy to be stored in the restricted volume of the rocket tanks. In the case of the *Titan* military rocket, for instance, it is intended to replace the propellants at present used (liquid oxygen and kerosene) by nitrogen tetroxide and hydrazine, as in the *Vega* third stage. This combination has higher combustion efficiency and an increased total impulse for the same tank capacity.

Some time ago certain doubts arose in the USA as to the suitability of liquid fluorine as a rocket propellant, and recent successful experiments with liquid hydrogen and liquid oxygen suggest that fluorine is now completely out of the running. Although Pratt & Whitney's projected lox/liquid hydrogen rocket engine is not yet operational, engineers are of the opinion that it will ultimately be possible to develop liquid hydrogen combustion chambers with thrusts of nearly ten million pounds.

There is, however, talk of developing fluorine-enriched solid-propellant powerplants to raise combustion efficiency, though it is still difficult to obtain a stable fluorine mixture in a solid propellant grain. In this connection it is interesting to learn that the USA is considering the development of solid-propellant rockets where the propellant accounts for 97 percent of the total weight. This extremely favourable ratio could be achieved by the use of combustion chamber casings of coiled steel wire or new fibreglass materials whose resistance to tear is higher than that of steel.

*

That space research in the coming years will have its fair share of setbacks as well as successes, appears inevitable. But the future should make it clear that the best results are not always obtained with the most powerful boosters. Space travel, the most important aid to space research, is still subject to keen competition which, backed as it is by military credits, amounts almost to an "armaments race." But, the greater the number of nations engaged in intensive research, the sooner will this warlike attitude give way to a willingness to cooperate in the interest of science. It may, however, become increasingly difficult to justify the voting of billion-dollar credits if national ambition has cooled down. There will be no room for flights of fancy in already overburdened budgets, but even the most prosaic results of this new branch of research will be fantastic enough. ↔



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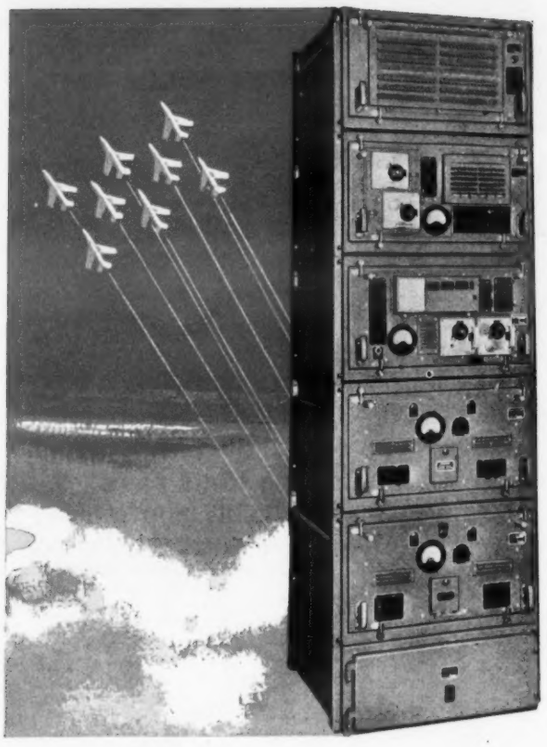

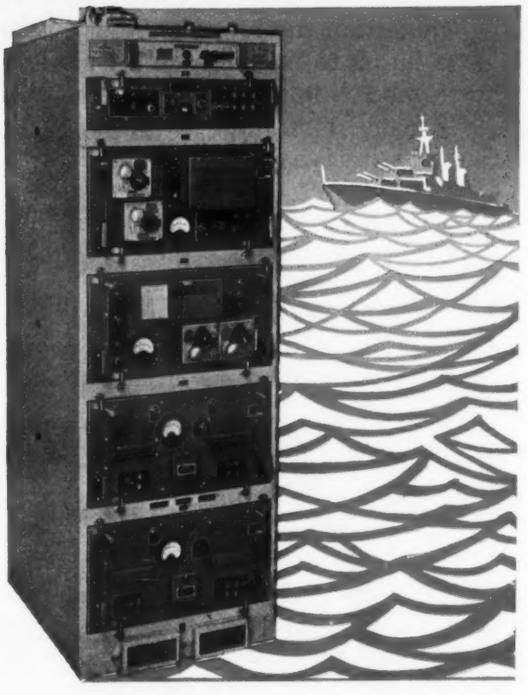

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To meet this need, on the battlefield, in the air and at sea, The Plessey Company, in collaboration with various Government Research and Supply Establishments in Great Britain, has produced a comprehensive range of transmitting and receiving equipment, each specifically designed for its particular application.

For the British and Commonwealth Armies, short-range speech contact to armoured fighting vehicles in the forward areas is maintained with maximum clarity by V.H.F. equipment incorporating revolutionary improvements in electronic and mechanical efficiency. This equipment provides the practical solution to instantaneous communication in mobile warfare.

In meeting the different demands of the air and naval forces, the Company has developed and manufactured Ultra High Frequency equipment, which operates over the whole military UHF band of 225–400 megacycles, providing 1750 as against the existing 560 VHF channels. (A variation is available with 50 Kc/s bandwidth, giving 3500 channels.) Independent of any other form of radio communication activity, it is free from interference and fading and is the most advanced communications equipment of its kind.

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Flight Testing the X-15

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North American Aviation, Inc.

North American's test pilot Scott Crossfield has already been testing the X-15 rocket research aircraft for over six months, but it was only gradually that he ventured to heights of over 60,000 ft and speeds around 1,500 m.p.h. During the tests he has mastered the most critical situations aboard his steel space vehicle, and on November 5th survived an explosion in the rocket engine of the second prototype of the X-15, making a forced landing in the Mojave desert. The third prototype is now ready to fly and soon, to the roar of its Thiokol rocket engine, it will climb into the stratosphere... However, the ultimate performance test, the leap into space at six or seven times the speed of sound, has yet to be made. Not until the end of this year will we know whether a USAF or NASA pilot has been able to direct the X-15 onto a weightless ballistic space trajectory, whether the vehicle, returning to earth from a height of some 100 miles has responded to the controls on re-entry into the atmosphere, and whether the steel airframe has resisted the infernal heat and the sudden force of air pressure.

Interavia has several times reported on NASA's thorough groundwork and North American engineers' meticulous preparations for the first flights of the two X-15 prototypes (cf. No. 4, 1959 and earlier issues). There now follows a recapitulation of the subsequent stages of this ambitious American aircraft programme since the X-15 began flight tests seven months ago.

The X-15 underwent its baptism of fire on June 8th, 1959, following six captive flights under the wing of a Boeing B-52 bomber. On the morning of this fine summer day there appeared in the sky above the Californian desert a small bright spot which, released from an eight-jet B-52 at a height of 38,000 ft a moment before, silently followed an elongated S curve. After about five minutes the X-15's characteristic flat fuselage could be recognised with the naked eye (the aircraft has scarcely any wings). Its nose tilted steeply upwards, the aircraft approached the runway on Rogers Dry Lake, flared out, dropped abruptly onto its iron landing shoes from a height of several yards and came to a halt, trailing an impressive cloud of dust. Fire-engines and ambulances raced across the salt lake... and found the pilot safe and sound. The X-15's airworthiness had been proved, though it had yet to make its first powered flight.

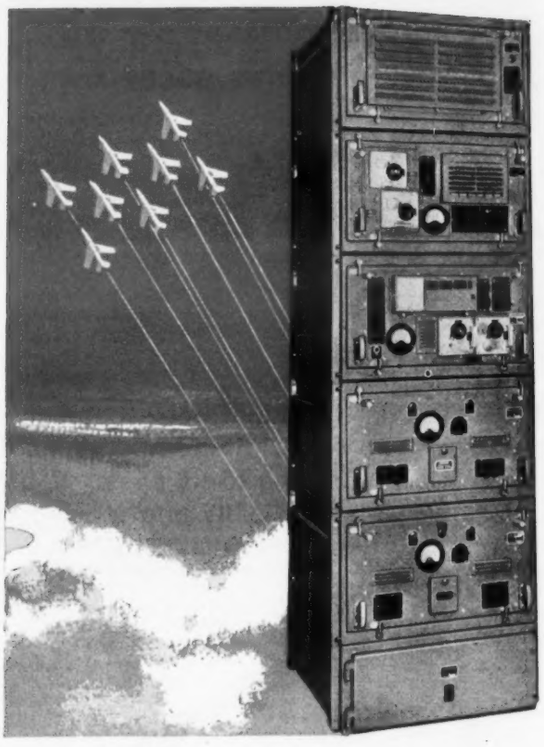
On September 17th, after a series of fruitless climbs under the wing of the mother aircraft, Scott Crossfield was again carried aloft in the X-15 and released at a height of 38,000 ft. This time he ignited the rocket engine and climbed almost vertically to an altitude of 50,000 ft. He then made a complete circuit with engines burning (to use up the propellant), and glided back to Edwards Air Force Base to land on Rogers Dry Lake ten minutes after release.—This phase, too, had been passed with flying colours. But the operational reliability of the provisional rocket powerplant (two Reaction Motors XLR-11 four-chamber engines) still left much to be desired. And the ultimate powerplant, the Thiokol XLR-99 single-chamber rocket engine, designed to deliver a thrust of about 50,000 lb, is still not operational.

The next powered flight, scheduled for October 10th, had to be postponed, when the X-15 had already reached a high altitude, as Crossfield discovered a fault in the fuel transfer system leading from the mother aircraft. A further attempt, to have been made on October 14th, was also cancelled due to technical difficulties. Three days later, however, the X-15 was successfully released at high altitude with increased fuel reserve. The rocket engine burnt for ten minutes, during which the X-15 reached speeds of about 1,500 m.p.h. and a height of about 60,000 ft. The spacecraft touched down on the salt lake according to plan at a speed of about 200 m.p.h.—once again Scott Crossfield had given proof of his considerable piloting skill. But he was to have yet another opportunity of demonstrating his sang-froid and high technical ability.

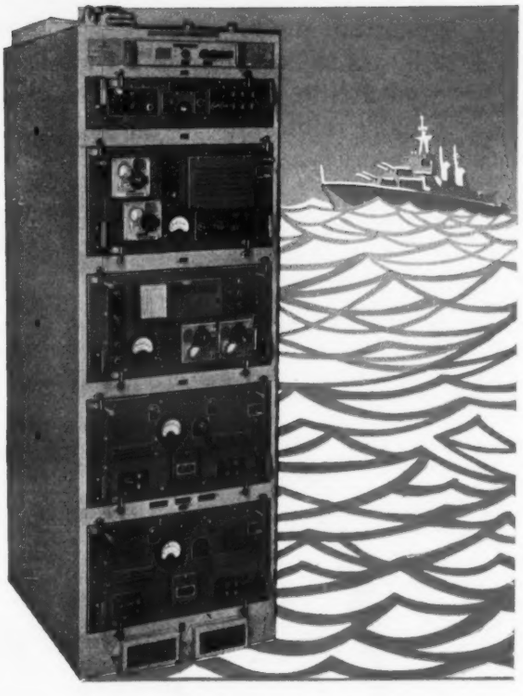
On November 5th, after release from the B-52, he was entering the dark stratosphere at full power in the second X-15 prototype when there was an explosion in the lower of the two rocket engines. Crossfield succeeded in jettisoning the entire fuel supply via emergency valves and bringing his burning aircraft down onto the landing ground. This time the landing did not go quite so smoothly: although the shoes under the fuselage rear were strong enough to withstand the shock of landing, the nose-wheel hit the ground so hard that the airframe broke in two between the fuel tank section and the forward fuselage. It has since been reported that North American is considering making certain modifications to the X-15's unconventional undercarriage. Crossfield escaped unharmed from the crash landing and, by his courage, saved the X-15 prototype from total loss.

Major Robert White, who had escorted the X-15 as an observer in his F-104, later said that Crossfield had made a normal landing approach. Even as he touched down the aircraft was in the prescribed attitude, so that it was uncertain

Landing after the first powered flight: crash tenders and fire trucks collect around the X-15. Firemen in the rear spray the propellant escaping from the rocket engine; in the foreground two men stand by ready to intervene if fire should break out in the hydrogen peroxide vaporizers.



Commanding Voice



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North American's test pilot Scott Crossfield has already been testing the X-15 rocket research aircraft for over six months, but it was only gradually that he ventured to heights of over 60,000 ft and speeds around 1,500 m.p.h. During the tests he has mastered the most critical situations aboard his steel space vehicle, and on November 5th survived an explosion in the rocket engine of the second prototype of the X-15, making a forced landing in the Mojave desert. The third prototype is now ready to fly and soon, to the roar of its Thiokol rocket engine, it will climb into the stratosphere... However, the ultimate performance test, the leap into space at six or seven times the speed of sound, has yet to be made. Not until the end of this year will we know whether a USAF or NASA pilot has been able to direct the X-15 onto a weightless ballistic space trajectory, whether the vehicle, returning to earth from a height of some 100 miles has responded to the controls on re-entry into the atmosphere, and whether the steel airframe has resisted the infernal heat and the sudden force of air pressure.

Interavia has several times reported on NASA's thorough groundwork and North American engineers' meticulous preparations for the first flights of the two X-15 prototypes (cf. No. 4, 1959 and earlier issues). There now follows a recapitulation of the subsequent stages of this ambitious American aircraft programme since the X-15 began flight tests seven months ago.

The X-15 underwent its baptism of fire on June 8th, 1959, following six captive flights under the wing of a Boeing B-52 bomber. On the morning of this fine summer day there appeared in the sky above the Californian desert a small bright spot which, released from an eight-jet B-52 at a height of 38,000 ft a moment before, silently followed an elongated S curve. After about five minutes the X-15's characteristic flat fuselage could be recognised with the naked eye (the aircraft has scarcely any wings). Its nose tilted steeply upwards, the aircraft approached the runway on Rogers Dry Lake, flared out, dropped abruptly onto its iron landing shoes from a height of several yards and came to a halt, trailing an impressive cloud of dust. Fire-engines and ambulances raced across the salt lake... and found the pilot safe and sound. The X-15's airworthiness had been proved, though it had yet to make its first powered flight.

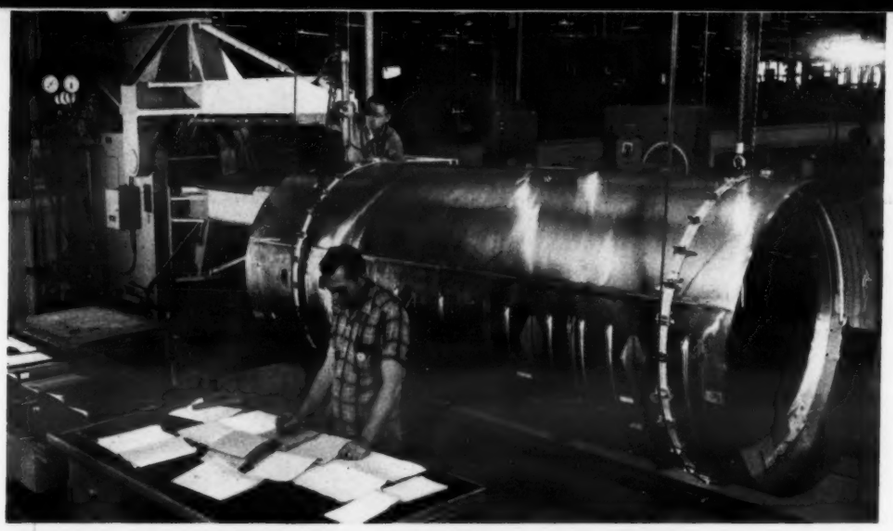
On September 17th, after a series of fruitless climbs under the wing of the mother aircraft, Scott Crossfield was again carried aloft in the X-15 and released at a height of 38,000 ft. This time he ignited the rocket engine and climbed almost vertically to an altitude of 50,000 ft. He then made a complete circuit with engines burning (to use up the propellant), and glided back to Edwards Air Force Base to land on Rogers Dry Lake ten minutes after release.—This phase, too, had been passed with flying colours. But the operational reliability of the provisional rocket powerplant (two Reaction Motors XLR-11 four-chamber engines) still left much to be desired. And the ultimate powerplant, the Thiokol XLR-99 single-chamber rocket engine, designed to deliver a thrust of about 50,000 lb, is still not operational.

The next powered flight, scheduled for October 10th, had to be postponed, when the X-15 had already reached a high altitude, as Crossfield discovered a fault in the fuel transfer system leading from the mother aircraft. A further attempt, to have been made on October 14th, was also cancelled due to technical difficulties. Three days later, however, the X-15 was successfully released at high altitude with increased fuel reserve. The rocket engine burnt for ten minutes, during which the X-15 reached speeds of about 1,500 m.p.h. and a height of about 60,000 ft. The spacecraft touched down on the salt lake according to plan at a speed of about 200 m.p.h.—once again Scott Crossfield had given proof of his considerable piloting skill. But he was to have yet another opportunity of demonstrating his sang-froid and high technical ability.

On November 5th, after release from the B-52, he was entering the dark stratosphere at full power in the second X-15 prototype when there was an explosion in the lower of the two rocket engines. Crossfield succeeded in jettisoning the entire fuel supply via emergency valves and bringing his burning aircraft down onto the landing ground. This time the landing did not go quite so smoothly: although the shoes under the fuselage rear were strong enough to withstand the shock of landing, the nose-wheel hit the ground so hard that the airframe broke in two between the fuel tank section and the forward fuselage. It has since been reported that North American is considering making certain modifications to the X-15's unconventional undercarriage. Crossfield escaped unharmed from the crash landing and, by his courage, saved the X-15 prototype from total loss.

Major Robert White, who had escorted the X-15 as an observer in his F-104, later said that Crossfield had made a normal landing approach. Even as he touched down the aircraft was in the prescribed attitude, so that it was uncertain

Landing after the first powered flight: crash tenders and fire trucks collect around the X-15. Firemen in the rear spray the propellant escaping from the rocket engine; in the foreground two men stand by ready to intervene if fire should break out in the hydrogen peroxide vaporizers.



The welded Inconel X propellant tank forms part of the fuselage structure. Completely new welding processes had to be developed for this extremely hard, heat-resistant alloy. Left, the special welding machine.

whether the break in the fuselage was in fact due to pilot error, or to the failure of a fastener. Air Force Flight Test Center engineers have meanwhile been examining the dismantled engine and tank system in the hope of discovering the cause of the explosion. As soon as this has been found, flight tests will continue with prototypes Two and Three.

So much for test flights up to the present; these will shortly be followed by more ambitious excursions into space. As, however, all X-15s are for the time being fitted only with two small XLR-11 rocket motors, even these later tests are not likely to reach the performance limit which the manufacturer must investigate before NASA can begin the X-15 programme proper. Only then will this manned space laboratory, carrying over 1,300 lb of instruments, be able to penetrate to the edge of the earth's atmosphere and perform the tasks for which it was created.

Although the X-15 programme dates back to 1952, it will therefore still be some time before space can be probed with manned vehicles.

Below is a brief summary of the most important dates in the X-15's development.

April 1952	Resolution passed by NACA directing laboratories to initiate hypersonic research with manned experimental aircraft. The proposals already envisaged flights to the edge of the earth's atmosphere and took account of the physiological aspects of astronautics.
May 1954	NACA established specifications for the projected experimental aircraft.
July 1954	Formation of a special X-15 committee consisting of representatives of NACA, the Air Force Scientific Advisory Board and the Office of Naval Research.
December 1955	Choice of North American design and award of a development and construction contract for three aircraft.
September 1957	Construction began at North American's Los Angeles plant.
October 1958	First aircraft completed.
June 1959	First glide flight.
September 1959	First powered flight.

Although *Interavia* has already reported on the principal structural features of the X-15, its jet-nozzle controls (for the ballistic phase), the pressurized tank system, the inertial guidance system, and the thousand and one measuring devices, many details, only recently released by the USAF, have yet to be added.

First, the airframe: all external surfaces are of Inconel-X, a nickel alloy resistant to extremely high temperatures, which raised new fabricating problems, particularly as regards welding. The internal structure is of Inconel X, titanium and aluminium alloys, with the latter being used only where no high heat loads are encountered. Some 65 percent of the X-15 components are welded together, while the remainder are riveted or screwed. After a typical space glide temperatures of up to 650°C occur at the wing and tail leading edges and the fuselage nose, while at other points of the airframe temperatures fall to as low as —175°C. The situation is still further complicated by the low storage temperatures required for the rocket engine's liquid oxygen and the local high temperatures of parts of the gas and hydraulic system, in which pressures of up to 4,000 p.s.i. occur. New hydraulic fluids also had to be developed, to work satisfactorily at the lowest and highest temperatures and even in the event of abrupt changes of temperature inside the pipes. The same applied to the hydrogen peroxide turbines for the auxiliary power units. The cockpit and certain electronic components are cooled by means of liquid nitrogen (storage temperature around —195°C), which is also used for cockpit pressurization.

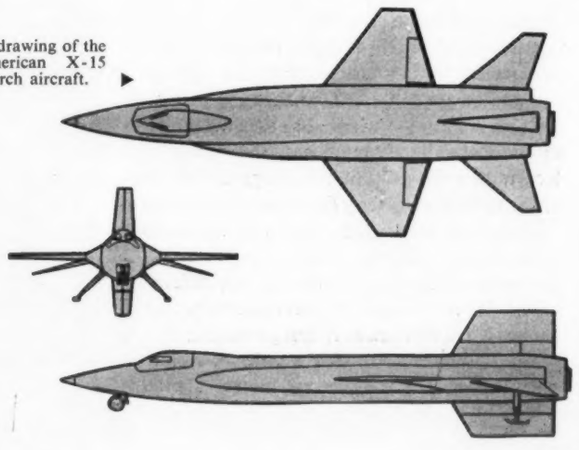
The powerplant, main problem child in the X-15 programme, consists at the moment of two XLR-11-5 rocket engines, working on liquid oxygen and alcohol. These engines were already fitted in the well-known X-I series of NACA research aircraft and deliver 8,000 lb of thrust each for a total of 16,000 lb. However, the XLR-99 engine originally projected for the aircraft and still under development is designed to deliver no less than 50,000 lb of thrust. More than 10,000 lb of liquid oxygen and liquid ammonia per minute

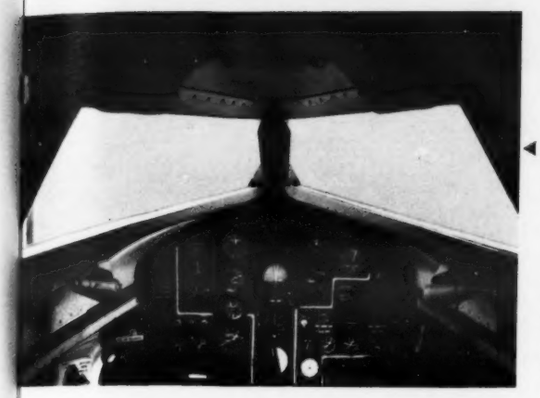
◀ Months of laboratory tests were required before the ideal design was found for the streamline pylon to support the X-15 beneath the B-52 wing. Each of the quick-release fasteners and contacts between the research aircraft and the B-52 also underwent searching tests.

Technical Data for the North American X-15

Length	50 ft	Total fuel weight	19,000 lb
Span	22 ft	Max. design Mach No.	Mach 7
Height (overall)	13 ft	Ultimate acceleration at full engine thrust, shortly before burnout (in climb)	approx. 5 g
Wing area	200 sq.ft		
Wing sweep at 25% chord	25°	Design max. speed	3,600 m.p.h.
Gross take-off weight (on release from mother aircraft)	31,275 lb	End of re-entry at 80,000 ft and 3,000 m.p.h.	

Three-view drawing of the North American X-15 rocket research aircraft. ▶

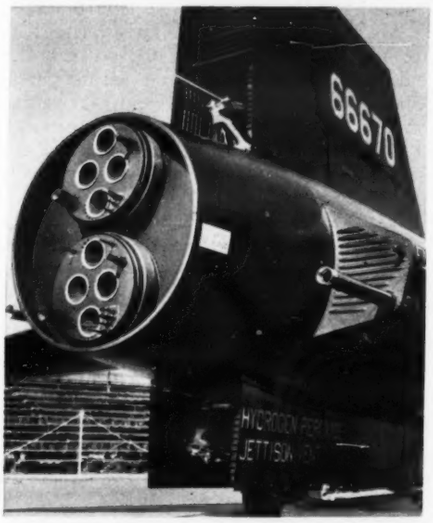




◀ Inside the cockpit: Centre top, slip indicator; top right, inertial height and inertial speed indicator for the ballistic phase (up to 990,000 ft and 7,000 ft/sec); right, next to the Flight Director, an inertial vertical speed indicator, also for the ballistic phase (up to 1,000 ft/sec); top left, accelerometer (up to 12 g); far left, flight instruments for the subsonic range.

Final preparations for the take-off beneath the B-52. Scott Crossfield is in the cockpit, and a mechanic is fastening the helmet of his pressure suit.

must be pumped from the propellant tanks into the XLR-99 combustion chamber to maintain this thrust. Furthermore, the thrust must be continuously controllable, and the engine capable of being cut out and restarted at will. To avoid the consequent danger of explosion, steps must be taken to ensure that not more than one pint of propellant accumulates in the combustion chamber, as the ignition of a large quantity of the highly explosive propellant mixture would destroy the engine or even the whole aircraft. The critical amount of 0.4 lb of liquid ammonia and 0.5 lb of liquid oxygen would accumulate in the space of 5 milliseconds if full propellant feed were maintained. This danger is eliminated by extremely fine automatic flow and pressure regulation in the propellant feed system. One advantage of the XLR-99 engine is its idling capability, which enables the X-15 pilot to check the most important engine functions immediately after starting up the turbo pumps, while the X-15 is still attached to the mother aircraft.



Fuselage rear with the eight nozzles for the two XLR-11 four-barrel rocket engines used in the present prototypes. At the rear edge of the two-part fin are hydraulically operated speed brakes, at the rear of the fuselage bulges are pipes for propellant jettisoning.

The liquid oxygen and ammonia are fed to the combustion chamber by a turbo pump, whose turbine is actuated by decomposed hydrogen peroxide; while helium gas is used to pressurize the propellant tanks and the propellant jettison system. The total propellant, weighing 19,000 lb, is sufficient for a burning time of roughly 90 seconds, but must be jettisoned within a few seconds in an emergency. Needless to say, the engine can be re-used on several occasions.

Of special interest is the XLR-99's combustion chamber, which—like most liquid-propellant rockets—is cooled by the regenerative process, i.e., by fuel circulating in the hollow chamber walls. It was found that combustion chambers cooled in this way show a tendency to overheating when power is throttled back (because of reduced fuel flow) and finally explode.

Overheating of this kind has been overcome in the XLR-99 by special design of the whole chamber and of the steel tubes forming the wall ("spaghetti" structure). To protect the chamber walls from flame erosion (2,740 °C), the whole of the chamber interior is lined with Rokide Z, a ceramic developed by the Norton Company. The wall thickness of the combustion chamber steel tubes is only 0.035 in. The finished chamber is wire-wound and coated with an epoxy binder.

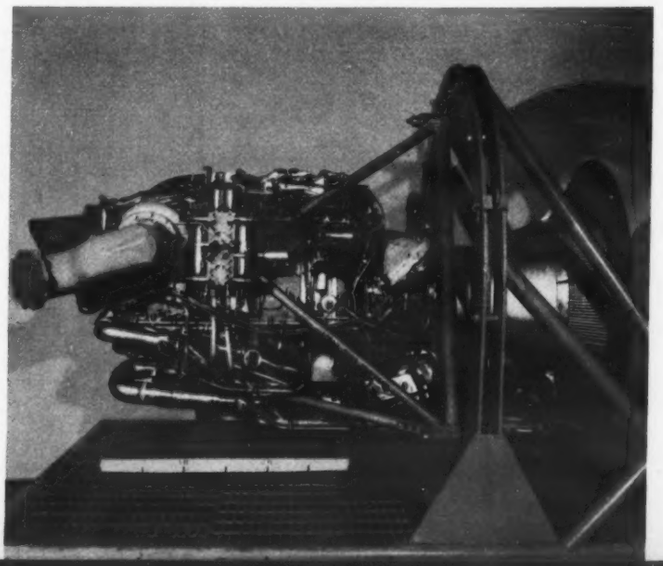
The following are the major characteristics of the XLR-99-RM-1:

Dimensions: length 6 ft, width 3 ft.
Weight: approx. 750 lb.
Thrust: 50,000 lb plus.
Thrust/weight ratio: 60–70 : 1.
Mixing ratio (liquid oxygen to liquid ammonia): 1.25 : 1.
Specific impulse: roughly 250 sec.
Combustion temperature: 2,740 °C.
Chamber pressure: 600 p.s.i.
Ignition: electrical.

As mentioned in Interavia No. 4, 1959 (p. 392), considerable difficulty was experienced in developing the two auxiliary power units to drive the hydraulic pumps and generators. As the X-15 operates over a wide temperature and acceleration range, the specifications handed to General Electric for the turbo-steam generators were stringent, since this equipment has to function perfectly throughout the weightless phase under space conditions. The expanded steam is also used in pressure nozzles for control purposes. The hydraulic system controls the differentially actuated combined elevators and ailerons at the rear of the fuselage, the rudder, the main speed brakes and the landing flaps (two separate 3,000 p.s.i. systems), while the electrical system is used primarily to supply the flight instruments and the extensive measuring equipment. The nose-wheel undercarriage and tail skid are lowered purely mechanically, by making use of gravity and the air flow.

◀ Rear fuselage with rudder unit and tailplane. The lower portion of the fin has been removed, the skids have been raised to the fuselage belly, and the tail rests on a trolley.

The Thiokol XLR-99, final powerplant for the X-15. Left, the turbo pumps for propellant feed, right the jet nozzle. ▶



Retraction (once the X-15 has been suspended from the mother aircraft) is done by means of a hand crank.

*

The X-15 not only carries 740 temperature and pressure pickups distributed over the whole airframe surface (the X-2 had only 15 temperature pickups and no pressure pickups), but also contains equipment to monitor the pilot's physiological behaviour. For some ten years flight test engineers have been using a wide variety of methods of simultaneously transmitting back to the ground the data recorded during test flights and of displaying these data in readily comprehensible form while the flight is still in progress. Never before, however, has any attempt been made to record the pilot's behaviour under the extreme conditions of a space flight. In the X-15 programme man too becomes an object of measurements. Telemetry transmitters aboard the North American vehicle will continuously send data on blood pressure, heart beat, body temperature etc., and typical reactions, to a ground station where a USAF medical officer will examine the information presented on oscillographs. Special attention will also be given during the test flights to the cockpit and pilot equipment, in particular the MC-2 space pressure suit developed for the X-15. This suit incorporates 24 electrical contact points which can be connected by cable to the physiological sensors or transducers and the telemetry transmitters. Initially, however, only pressure differential values (cabin pressure to suit pressure, suit pressure to helmet pressure, etc.) will be recorded, as these are of primordial importance to the pilot's comfort and safety. Since, for structural reasons, there is a differential of only 3.5 p.s.i. between the cockpit pressure and the external pressure, it was not considered feasible to fill the whole cockpit with a breathable mixture of nitrogen and oxygen. This would have necessitated enriching the cockpit atmosphere with 86 percent oxygen, which would entail severe fire and explosion hazards, particularly as the walls become red hot during certain flight phases. Instead the pilot's helmet is pressurized with 100 percent oxygen. The remainder of the suit—separated from the helmet by a rubber seal at the neck—and the cockpit are ventilated with non-inflammable nitrogen.

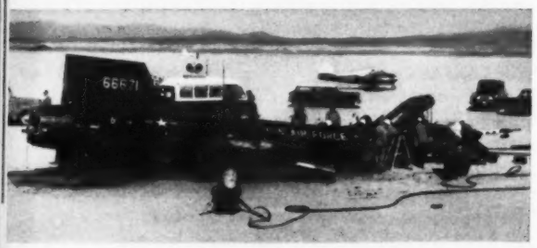
All the instruments and equipment developed for observing the pilot's physiological condition have been tested by the Air Force Flight Test Center in a Convair TF-102A two-seat jet fighter. The pilots on the X-15 programme also familiarized themselves with the MC-2 pressure suit in this aircraft, though of course these flights formed only part—and a very small part—of the NASA programme designed to send the X-15 men on their dangerous mission to the outer limits of human endurance. Other preparations included acceleration tests in the big centrifuge at the Naval Air Development Center, Johnsville, Pennsylvania, hours of detailed training in North American's X-15 simulator at Inglewood, California, rapid descents from extreme altitudes in an F-100, weightless flights in a converted C-131B, etc.

Not until these training and test phases have been completed can the selected pilots set out on their space adventure, to prove that the United States Government has not spent $121 million in vain on this programme. The present article should give a fairly good idea of where this impressive sum will have gone. For example, four thousand hours of wind tunnel research were required before the X-15's ultimate configuration could be determined—far more hours than the total the aircraft is ever likely to achieve in the air—not to mention the millions of manhours of highly skilled labour.

Besides this programme, however, the U.S. National Aeronautics and Space Administration is also financing new pioneer developments such as *Mercury* and *Dynosoar*, designed to take man still further out into the exosphere. The price which the Great Powers must pay for space travel is indeed a high one. ◆◆

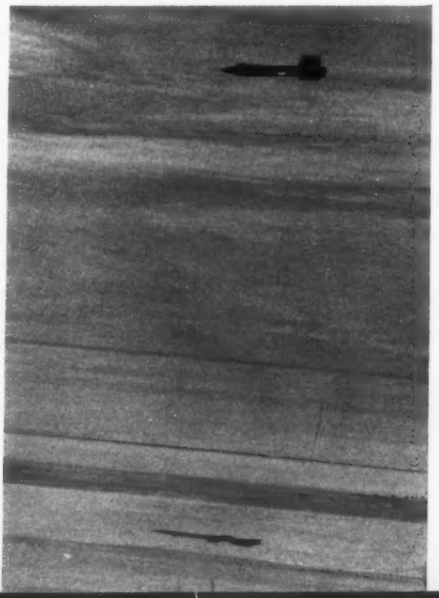
The X-15 is carried to an altitude of some 38,000 ft beneath the starboard wing of the B-52 mother aircraft.

The mother ship takes off with the X-15 in place.



The second X-15 prototype makes an emergency landing in the Mojave Desert on November 5th, 1959. The hard impact caused the fuselage to break apart behind the cockpit.

Landing after the first free flight: The X-15 approaches the salt track at Edwards AFB at almost 250 m.p.h., touches down with nose well up and slides to a standstill on tail skids and nose wheel. The pilot uses the aircraft's shadow to judge his altitude. Throughout the flight and landing phases he receive radioed corrections or warnings from the pilot of the escorting F-104.



Aerodynamics in the New Decade

By B. P. Laight, Director and Chief Designer, Blackburn Aircraft Ltd., Brough, Yorkshire

Before embarking on discussion of such a wide topic as aerodynamics, we must first define our terms of reference. To the scientist, aerodynamics means the study of gases in motion, which of late has extended from the treatment of the gas as a fluid to the study of types of flow in which molecular motion and heat transfer are of importance. Defined in this way aerodynamics as a subject finds application in such widely separate fields as turbine engines and ballistic missiles.

However, to the practising engineer concerned with aeroplanes, the term aerodynamics has a more limited meaning: namely the study of air flows and their resulting forces on an aircraft which must precede any detail design work to ensure that the completed flying machine will be satisfactory. This is the definition applied for the purpose of the present short article, which will indicate the problems likely to be worked on during the 1960s by discussing in turn the types of aircraft, classified according to their aerodynamic principles, which may be built during that period.

The subsonic aeroplane

The classic subsonic transport aeroplane, whether military or civil, with speeds up to—say —Mach 0.75, is a useful vehicle which will be with us for as long as can be seen ahead. Over the last ten years its aerodynamics have not changed appreciably; in fact, its main development has been in propulsion, which has given it greater speed and altitude, and it may be that development in the future will take the form of continued engineering refinements of the basic principle rather than radical change. There is certainly room for many different designs among the variables of size, speed, range, type of engine etc., without breaking essentially new aerodynamic ground.

There are, however, two areas of work which might lead to a radical change in the subsonic aircraft. These are the use of boundary layer control (BLC) for reduction of drag and for increase of lift respectively. In both cases the aerodynamic principles are now well understood, and for any proposed application there are wind tunnel and other ground test techniques to provide aerodynamic design data. BLC requires the pumping and distribution of relatively large quantities of air, and this has lately become a much more convenient matter with the advent of the turbine engine.

BLC for high lift: The removal or re-energising of the boundary layer at places where it encounters adverse pressure gradients and tends to separate has been known for some time as a means of obtaining high lift. *Figures 1, 2 and 3* illustrate the results obtained in early tests on flap blowing in the Blackburn Wind Tunnel some five years ago.

There is interest, however, in examining the question of what types of aircraft are suitable for BLC by blowing. One important factor here is the ratio of the mass flow in the engines to the mass flow in the wing boundary layer. Other things being equal, BLC becomes more effective as wing loading and thrust-to-weight ratio are increased, and as speed is decreased (speed in this case being the take-off or landing speed at which the high lift is desired). It may be noted that BLC of this type has been found worthwhile, in project studies, when the mass ratio has been 5.0 or greater. The system is used in the Blackburn NA.39, for which the mass ratio is 6.

High lift coefficients are mainly required in the landing and take-off phases, but can also be of interest in high altitude manoeuvring, particularly in military aircraft. Here again we have a separation problem, but under very different flow conditions. The mass ratio is not greatly affected by altitude itself because thrust (in the numerator of the expression) is varying in much the same way as air density (in the denominator); but the higher speed can reduce the mass ratio to one fifth or less of its value at take-off and landing. Nevertheless, it has been found that BLC does have a beneficial effect on usable lift coefficients in high altitude manoeuvres.

BLC for low drag: For at least 20 years now engineers have sought means of reducing drag by applying BLC to the achievement of laminar flow in the boundary layer. The resulting improvement in cruising economy is so great that this subject is bound to remain in designers' minds, but the practical difficulties have so far prevented any useful design from emerging. One of these difficulties is the need for an incredible accuracy of contour, which can be upset by natural impurities in the atmosphere.

The use of BLC to bring the drag of bluff shapes to an acceptable level is also something which might receive more attention. Apart from the cusped aerofoils which seemed to be of some interest a few years ago, there has been very little thought given to this line of development.

It may well be that no very great progress will be made in the 1960's towards reducing drag below current levels, but because of the problem's overwhelming importance, work ought to continue in the hope that some way of engineering such drag reductions will be found.

STOL: This is a vague but by now a well used term which has come to apply to a class of aeroplane which take off and land at low speeds. Although some conventional aeroplanes with low wing loading have laid claim to being STOL aircraft, it is generally accepted that true STOL machines will show some new aerodynamic feature leading to high lift coefficients. One such feature, which still remains to be exploited, is the jet flap.

It is known that if large quantities of air are ejected in a downward direction at the trailing edge, a jet sheet is formed which can act as a flap. Resulting pressure changes on the fixed wing (although not those on the jet sheet) give extra lift. In extreme cases lift coefficients of over 10, expressed in terms of the fixed wing area, have been obtained.

The subject of high lift may be taken one stage further. Instead of being used to reduce take-off and landing speeds, high lift can equally well be applied to reducing wing area, leaving take-off and landing conditions unchanged. Such aircraft then offer better cruising economy because of reduced wing drag. If the jet flap is to come from the experimental stage in the 1960's, either this type of aeroplane or the STOL aeroplane may be the application.

VTOL: Now that the thrust/weight ratio of some special jet engines is greater than the lift/weight ratio of wing structure, it is clearly possible to design efficient aeroplanes which, at the instant of take-off and landing, are supported entirely by the thrust of downward deflected jet engines. It might be thought that, since there is no general air flow over the aircraft at this moment, the aerodynamic problems of take-off and landing would have disappeared, and that the shape of the aircraft could be designed for the cruise condition only. However, this is not the case. The performance, stability and control problems of the transition from complete engine lift to complete

Blackburn NA.39 low-level strike aircraft with slits for boundary layer blowing (see arrows) on wing leading edge, wing upper surface (in front of aileron) and on tailplane.

wing lift are very considerable. Moreover the lift engines themselves have a profound influence on the layout of the aircraft; although their weight may not raise problems, their disposition in a suitable manner certainly does. To ensure that adequate lift and control remain in the event of failure of some of the engines, the whole group must be placed around the centre of gravity, which obviously will affect the aircraft's overall configuration. The same applies, to a less extent, to any attempt to arrange the intakes in such a way that extra lift can be obtained from suction on the intake radius.

Whether this system is used or alternatives such as propellers in the plane of the wings, problems of VTOL are going to call for the combined efforts of aerodynamicists and designers for many years to come.

Flight at high Mach number

The supersonic aeroplane, whether for military or civil purposes, represents a much greater undertaking than the subsonic, and the aeroplanes which we can expect to see depend very much more on what the demand is.

The years up to 1970 may well see the end of the long-range bomber as we know it now, with the missile being used for the delivery of the major weapon. Secondly, the need for the classic interceptor is diminished both by the absence of the bomber and by the fact that already much of the intercepting work can be done by missiles.

It is not to be concluded, however, that there will be no new manned military aircraft—at least until all forms of armament disappear. Instead of the classic fighter and bomber, we can expect to see more general-purpose aircraft capable of a wide range of duties concentrated mainly around attacking ground or sea targets. These aircraft, in their more advanced forms, will be supersonic and may also have VTOL capability. But since missiles will soon hold all the records for range, speed and height, and aircraft will be unable to compete with them in these qualities, economic factors will play an important part in deciding on future aircraft types. It is much easier to discuss what could be produced rather than what will be produced.

The same may be said of civil aircraft. There has been a wave of buying the new generation of large jets flying at high subsonic speed, and both airlines and manufacturers may need some time to prepare for the next stage. Moreover, experience with supersonic bombers has been so limited as to make the introduction of the supersonic civil aircraft much more difficult. Nevertheless, although the stake is high, the prize is equally high for the first in the field, and I should expect that before 1970—but probably not much before—it might be possible somewhere in the world to buy a ticket for a supersonic journey.

The question then is, what kind of aircraft will this be? One technical point of interest is how far sweep back can raise the critical Mach number, and a good deal of work has been done towards achieving, by suitable shapes, the equivalent of subsonic wing drag at speeds higher than M = 1.0. However, it now seems likely that the next jump in speed of civil aircraft will be to a Mach number well above that for which this can be done. What this Mach number will be is a subject of much investigation; after the drag rise in the region of M = 1.0 has been passed, the next natural barrier is the undefined heat barrier. Above M = 2.0, temperatures begin to be too high for light alloy, so that it might be tempting, in order to ease the engineering problems, to choose Mach 2 as the cruising speed of the first supersonic transport. But apart from the heating problem, supersonic aeroplanes can be shown to have the same economics up to a Mach number of at least 3.0. For this reason, the faster aircraft, once it had gained the confidence of the airlines, would outsell the slower, and hence a Mach 3 aeroplane may well be the first to appear.

The aerodynamic work for aeroplanes such as these is governed by the near impossibility of making changes of shape to aeroplanes once the design is finalized, at least without considerable delay to the programme. Hence the aerodynamic work must be extensive and thorough. The techniques required are much the same as those now in use.

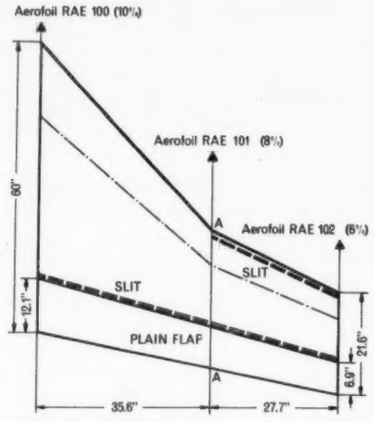


Fig. 1: Plan view of a half-wing model with plain flap which was tested in the Blackburn subsonic wind tunnel. The half-wing has RAE aerofoils of 10% thickness/chord ratio at the wing root and 6% at the tip; angle of sweep (dot-dash line at one quarter chord) is 40 degrees in the inboard portion, 20 degrees in the outboard portion. The lines of dashes indicate the slits designed to accelerate the boundary layer (see Fig. 2). Tunnel speed was 100 ft/sec.

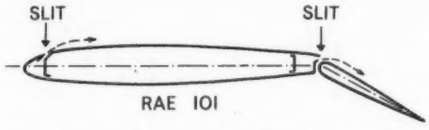
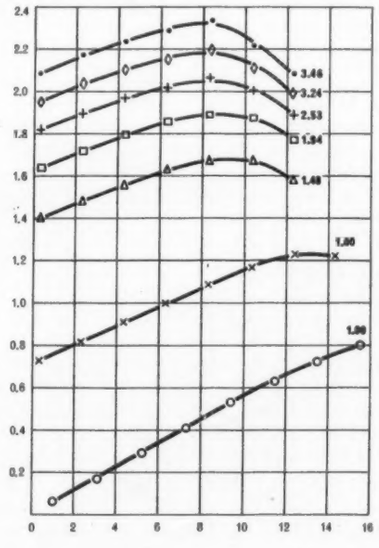


Fig. 2: Slit in the above model near the section A-A: RAE 101 aerofoil of 8% thickness/chord ratio; chord 28.5 inches; duct air temperature 120°C.

Fig. 3: Lift coefficients of the half-wing shown in Figs. 1 and 2, plotted against angle of incidence for various values of the ratio of slit pressure to free stream pressure (parameters). The top six curves are for 30° flap, the bottom curve for flap up. The parameter value of 1.0 indicates no blowing.



Some special problems

Internal flow: Aerodynamics has so far been discussed in connection with the flow around the outside of aircraft. It must not be forgotten, however, that internal flows of various types are becoming of increasing importance. Satisfactory intake performance, for example, is just as important as satisfactory wing or body drag. The problem of refrigeration and other aspects of air conditioning also require increasing attention. There appear to be no fundamentally new techniques for either of these, but in any new high performance aircraft they will call for the most careful experimental work and engineering design.

Noise: The noise problem is one which is with us now. It has already led to operational limitations on the large jets, and is in some ways the greatest handicap which can be seen for VTOL and other types of high powered aircraft. Although much has been done to make engines quieter than they would otherwise be, they are in fact still getting noisier, and the public is objecting. It would be unfortunate if aircraft capable of operating from small spaces in cities were banished because of their being too noisy.

Hovercraft: The hovercraft is a vehicle for which the 1960's will be important years. Its appearance is such a recent matter that predictions as to where it is going are hardly to be expected, but it is clear that as engineering development progresses over the next few years, it will find a place among the other forms of transport. For aerodynamicists there is much to be done at present in the analysis of cushion types of air flow designed to provide efficient lift and ground clearance; this will merge into the study of more general flows, as forward speeds give rise to dynamic pressures comparable in magnitude to the cushion pressure. Fortunately, because of the hovercraft's simplicity (at present), experimental vehicles for research purposes can be built relatively cheaply, by aircraft standards.

*

Notwithstanding the fact that this article has kept to the aerodynamics of the manned aircraft depending on the atmosphere for lift and propulsion, it has been necessary to treat each subject very briefly. It is clear that the domain of aerodynamics is expanding, and that there is no shortage of new areas of work. But no country can put into use all the possible new types of aircraft that can now be envisaged, and although new aircraft will continue to require very careful engineering thought, the most vital thinking of all over the next ten years will be devoted to deciding not what *can* be produced, but what *should* be produced. Such decisions for the larger aircraft are now matters of national importance; aerodynamicists will have contributed to showing what aircraft are feasible and will have full responsibility for ensuring that they fly satisfactorily.

◆◆

The Ducted Fan

By G. M. Lewis, M. A., AFRAeS, Assistant Chief Engineer, Bristol Siddeley Engines, Ltd., Bristol

Aircraft designers and airline operators are constantly searching for more economical forms of powerplant—powerplants which will make possible profitable airline operation at lower fare levels. Bristol Siddeley Engines Limited has recently announced a new form of jet engine which meets this need—the ducted fan engine. The first of a series of the company's ducted fan engines, the BE.58 was shown to the public for the first time at the SBAC Display at Farnborough in September, 1959.

The new ducted fan engines have three substantial advantages over present-day jet engines. Their specific fuel consumption is some 10 percent lower than that of the best present turbojet, under subsonic cruising conditions, affording a substantial economy to both medium and long-range airliners. They are lighter than present jet engines in the same thrust range, enabling payload to be increased, and have a much lower noise level, making possible the elimination of a major nuisance suffered by those living near airports.

The main design feature which results in these advantages is the very high mass flow of air compressed by the fan, compared with that which passes through the combustion section of the engine. This is between one and a half times and twice the amount of air passing through the engine, as compared with the by-pass engine where only approximately half as much air passes through the duct as through the combustion section. This high mass flow results in the ducted fan engine having a lower jet velocity, which in turn results in a noise level ten to fifteen decibels lower than that of the best existing turbojets. This means that the noise heard on the ground as the aircraft passes overhead is less than half that experienced from an aircraft with a present-day turbojet or by-pass engine at the same height.

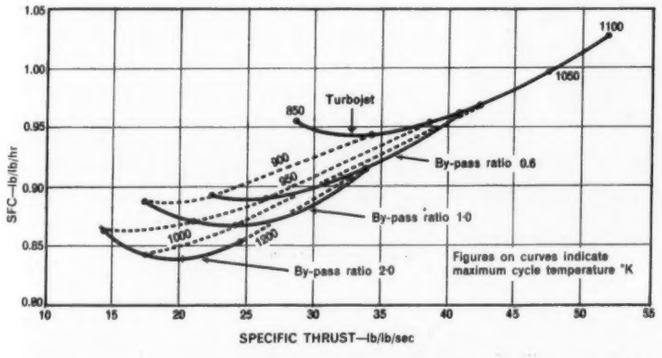
The high mass flow of the ducted fan also provides a high ratio of take-off thrust to cruise thrust and, since the engine size is normally selected on the basis of cruising performance, it follows that the ducted fan-powered aircraft will have a higher take-off thrust than the straight jet and a correspondingly shorter take-off run. This is expected to be as short as that of present day piston-engined and turboprop airliners.

As a direct consequence of its high propulsive efficiency, the ducted fan engine inherently has a low specific thrust. Nevertheless, two factors result in the Bristol Siddeley ducted fan engine having a thrust-weight ratio as good as or better than that of current turbojets. These factors are the good detail design of the engine, and the fact that in the case of the ducted fan the specific thrust is based on the total air flow, approximately three quarters of which does not pass through the compressor, combustion equipment and turbine, but merely requires a simple duct. The thrust of the Bristol Siddeley BE.58 is 14,500 lb for a weight of 2,600 lb, giving a thrust/weight ratio of 5.6 : 1; this is very close to that of the best turbojet of the optimum size and is substantially better than the thrust/weight ratio of turbojet engines in the same thrust range.

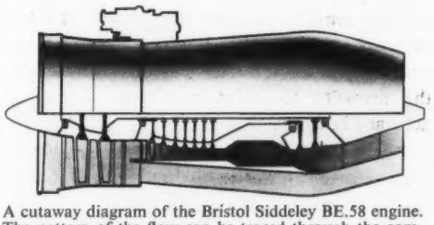
The overwhelming advantage of the ducted fan engine for civil transport aircraft flying at high subsonic speeds is its low fuel consumption. The specific fuel consumption of Bristol Siddeley ducted fan engines is some 10 percent lower than that of the best turbojet under cruising conditions. In the case of the BE.58, for example, the specific fuel consumption for cruising at 36,000 feet is 0.80 lb/lb/hr.

The advantage in fuel consumption compared with turbojet engines is even greater under take-off and climb conditions, since the ducted fan engine is inherently better suited to low flight speeds than the turbojet as a result of its low jet velocity. The specific fuel consumption of the BE.58 under sea level static conditions is 0.572 lb/lb/hr. The importance of this figure can be seen when it is appreciated that some current turbojet engines have a specific fuel consumption under the same conditions of over 1.0 lb/lb/hr.

Although the Bristol Siddeley range of ducted fans were the first to be built as ducted fans, as opposed to being adaptations of existing engines, a large number of components are closely similar to those already proven in tens of thousands of hours of operational service. Development of these engines, which has already begun on the test bench, is thus expected to go ahead rapidly to bring them to the high degree of reliability expected of a civil engine. ◆◆

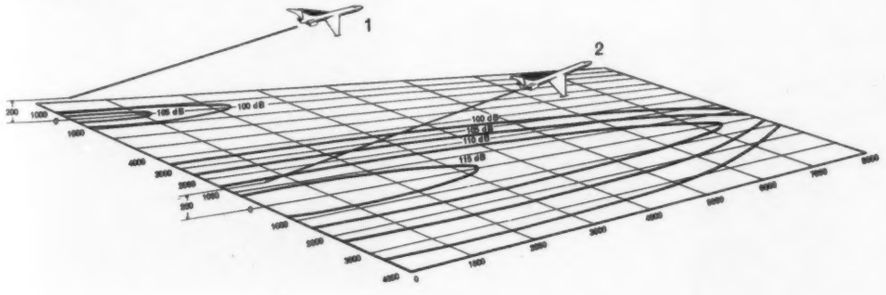


The graph illustrates the reduction in the specific fuel consumption of a ducted fan engine by the adoption of a high cold flow (by-pass) ratio. This is obtained at the expense of the specific thrust, but the BE.58 engine still retains a thrust weight ratio of 5.6 : 1.



A cutaway diagram of the Bristol Siddeley BE.58 engine. The pattern of the flow can be traced through the compressor and then dividing to pass through the duct and the combustion section.

A diagrammatic representation of the areas of noise intensity produced by a ducted fan (1) and a conventional jet aircraft (2). The patterns represent the noise levels produced in districts adjacent to the airport by two aircraft climbing from 200 feet.



Towards Better Pilot Aids

Today's Jet Age pilot knows his airplane is good. It has to be good to earn governmental approval. When the pilot settles in the left seat for each flight, he goes through the cockpit check with the confident assurance that his machine is the best modern engineering can produce. That means success of individual flights depends upon people. It depends upon his own personal skill, competence of his crew and maintenance personnel. He counts also on the men who assign and guard air space. With a realistic approach toward solution of traffic control problems, Jet Age air travel steadily will increase its proportionate share of the world's over-all transportation.

Herman R. Salmon
Chief Engineering Test Pilot,
Lockheed Aircraft Corporation

The date January 1960 affords a suitable opportunity to glance back at the decade of the 50's and recall some of the developments of the past 10 years. As far as piloting is concerned the period marks the beginning of the Jet Age in civil aviation, and Mr. Salmon offers the pilot's opinion of jet aircraft in his introductory foreword.

The past ten years have seen the introduction of both turboprop and turbojet aircraft to the world's air routes, but from the pilot's point of view the changes have not been merely the appearance of faster aircraft on the commercial scene. The jet aircraft has brought its own particular problems, but the chief problem has developed from the expansion of air traffic generally in the past ten years. While the basic techniques of piloting have remained the same, the external conditions have changed radically. The rapid increase in numbers of aircraft on the air routes together with increased speeds and performance has called for altered methods and standards of traffic control handling.

The apparently impossible has become possible, and the available airspace is in danger of saturation. From the pilot's point of view this has meant increased hazards from collision risk and the necessity to maintain a high degree of accuracy in flying.

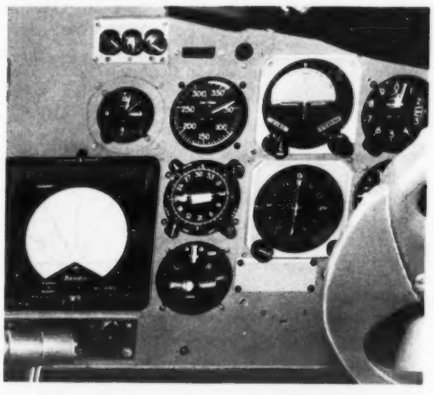
This need for increased flying accuracy has been reflected in the variety of equipment that has been developed during the past ten years. In the field of flight instrumentation the trend has been to combine as many functions as possible in the display on one instrument. By doing this the pilot is provided with a basic instrument to monitor and, by a selector switch, can choose whatever function is required for the intended manoeuvre. The Lockheed *Electra* panel illustrated on this page indicates this trend. The upper of the two central instruments provides the attitude information for the flight control of the aircraft in all conditions of visibility, while the lower displays the heading and director information. This flight director type of instrumentation (Collins FD-105 in the picture) is rapidly replacing the older layout where a separate instrument was required for each function.

Together with improvements in flight instrumentation the problem of navigation in a crowded airspace has produced both a variety of equipment and some heated controversy. Two basic systems have emerged; one typified by the Decca Navigator depending on a signal network emitted by a chain of ground stations, and the other the VOR/TACAN. The discussions that have ensued on the merits and demerits of the two systems have made one particular point apparent. A modern navigation system is not judged purely on its ability to guide an aircraft between two points, but on its capability of indicating the position of an aircraft accurately at any given moment. This is an indication of the crowded airspace conditions that the modern pilot has to compete with, and the necessity for pin point position accuracy at all times.

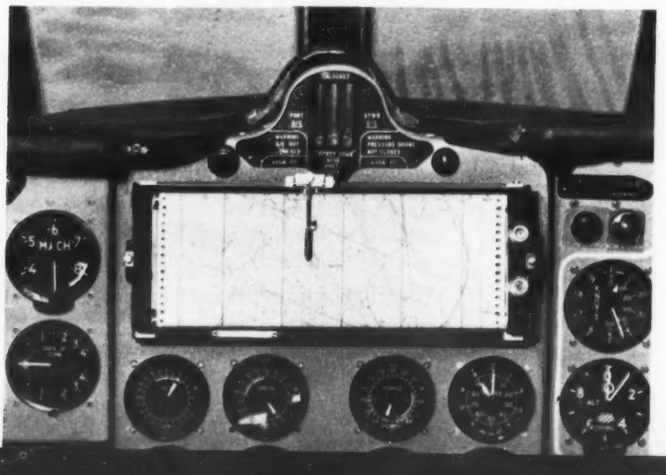
Turning from short range to long range navigation, one development of the last ten years is particularly noteworthy. The development of a Doppler radar system of a size and weight convenient for commercial aircraft offers a self-contained navigation aid requiring no ground transmission of a position indicating signal. At present undergoing evaluation by many airlines, the Doppler system will perhaps become the standard long distance navigation aid.

The rapid developments of the past ten years indicate the trend of the future. The development of the supersonic airliner will at last offer one added advantage over present-day types; it will open immense areas of as yet unused airspace which will simplify the tasks of both the pilot and the ground controller. ◆◆

● The co-pilot's panel of the Lockheed *Electra*. The photo illustrates the simplification of modern instrumentation with the main flight and navigation displays grouped on two dials.



● The Decca Navigator system installed in a *Comet* cockpit. This system represents a modern concept for en route navigation in crowded airspace, which continually indicates the aircraft's position to the pilot.



● An alternative navigation system for long distance routes. The Collins Doppler Navigator with the drift and ground speed indicator and (right) the two stage navigation computer control.

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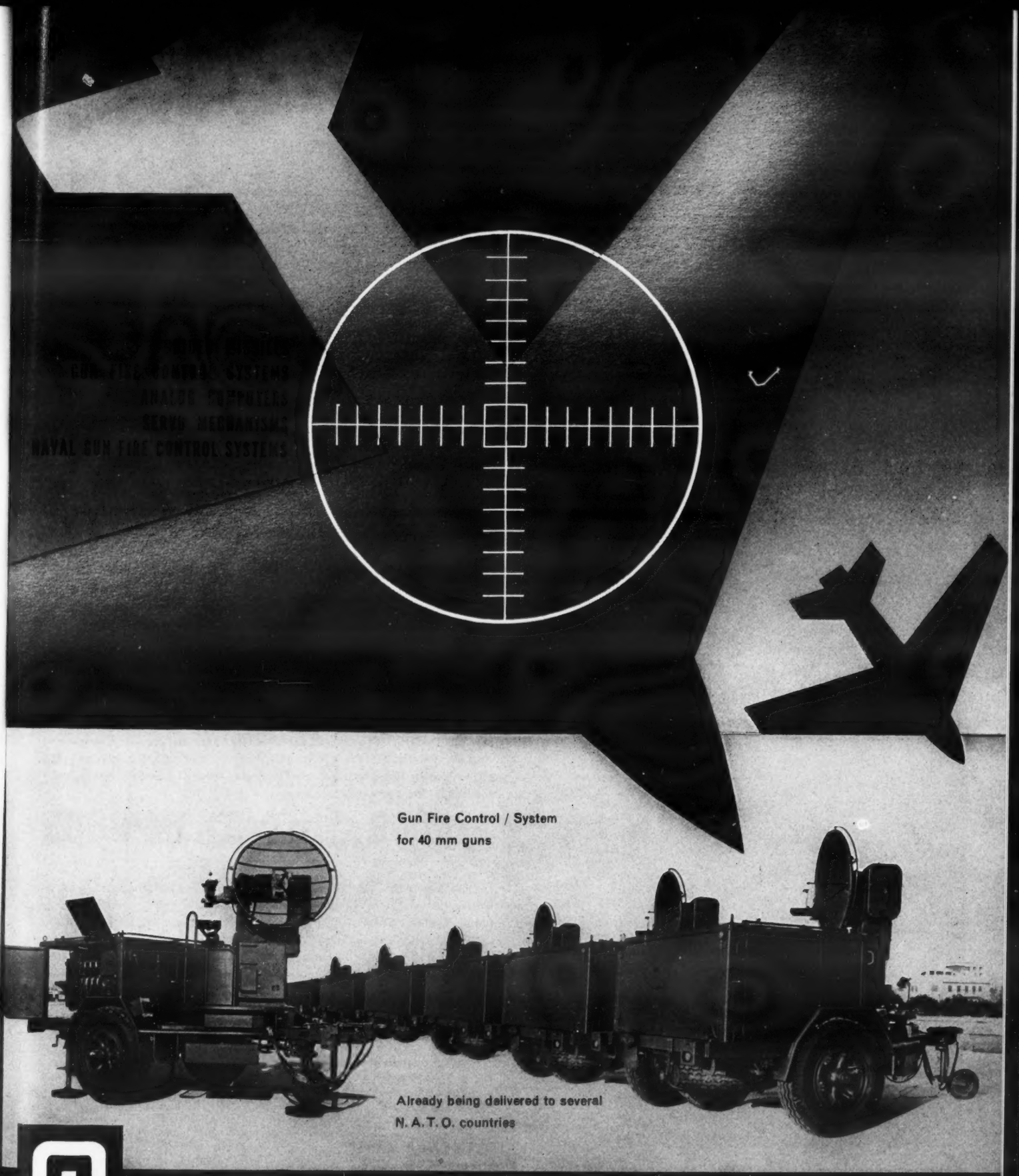

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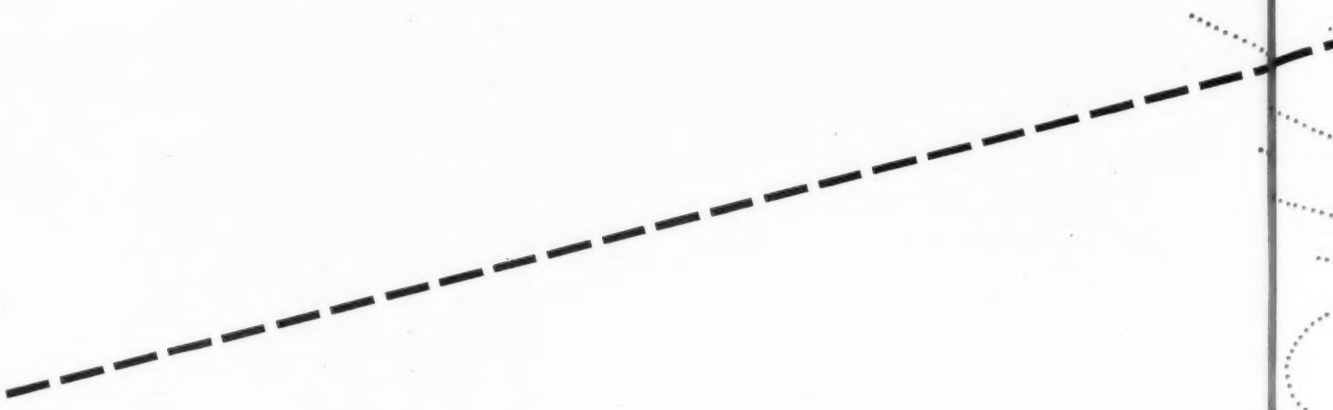

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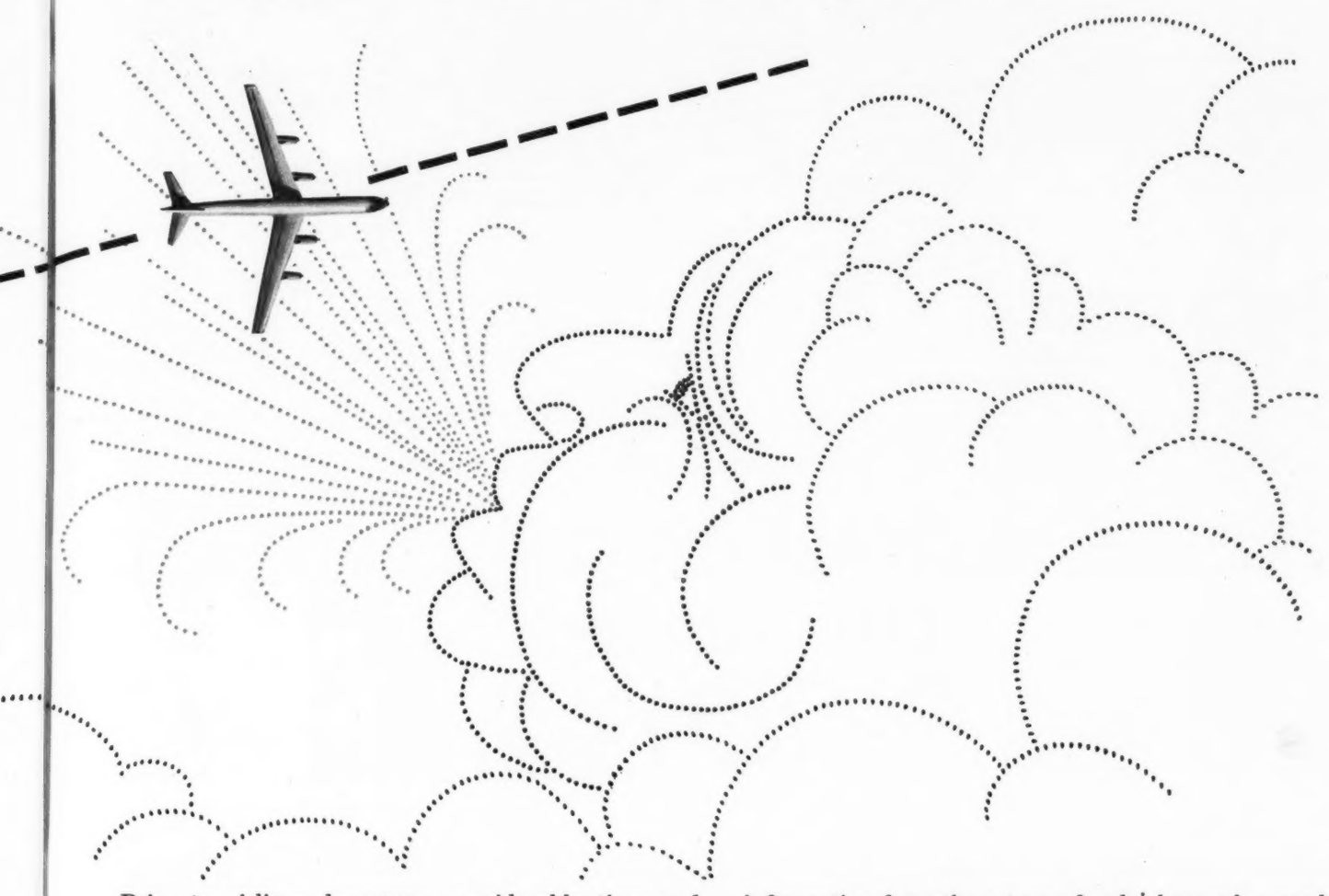

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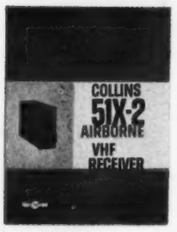

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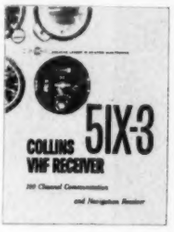

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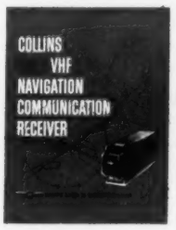

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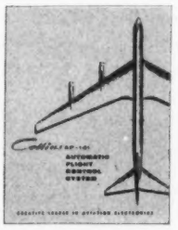

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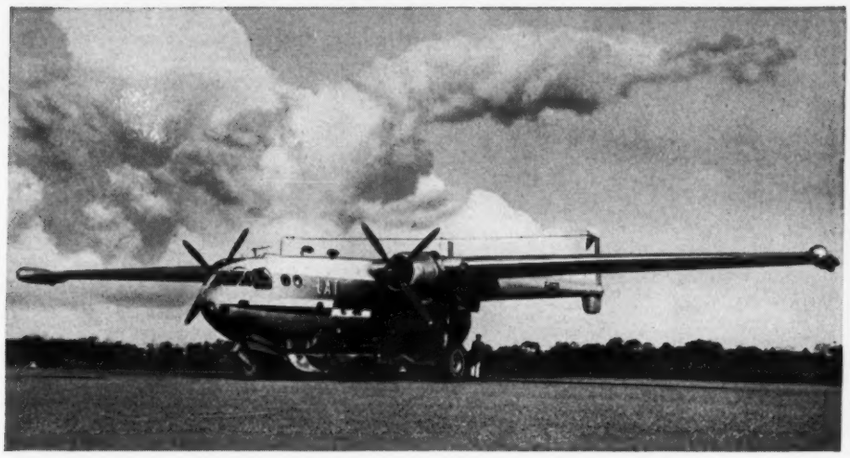

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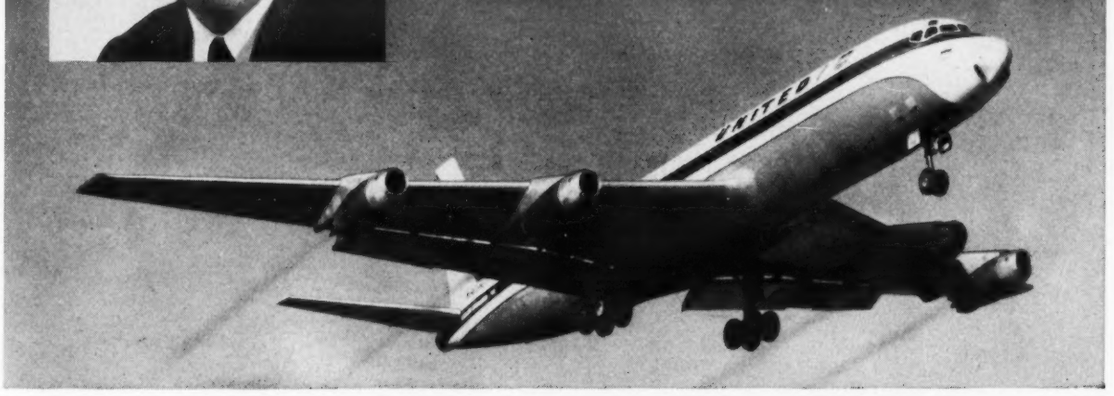

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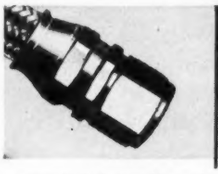
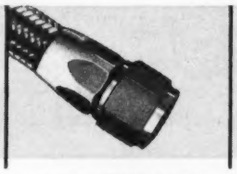


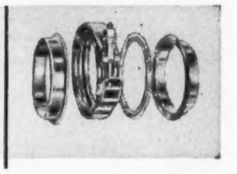
Aeroquip 666 Hose Lines of Teflon with patented* Reusable **"super gem"** Fittings serve special high-temperature applications.



Aeroquip 601 High Performance Hose Lines and Reusable **"little gem"** Fittings are used on engine fuel and lube oil systems.

Aeroquip 5420 Self-Sealing Couplings are used on refrigerant lines of the DC-8's air conditioning system.

Aeroquip Precision Formed Tubing with integral hose fittings achieves exceptional weight savings and eliminates potential leak points.



Marman V-Band Couplings, Channel Band Couplings, Instrument Mount Clamps and Band Clamps are used on the Douglas DC-8.

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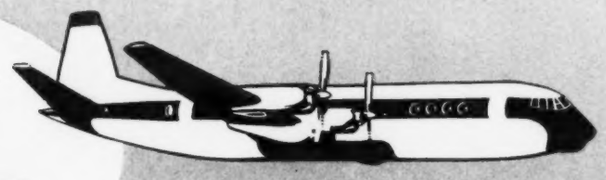
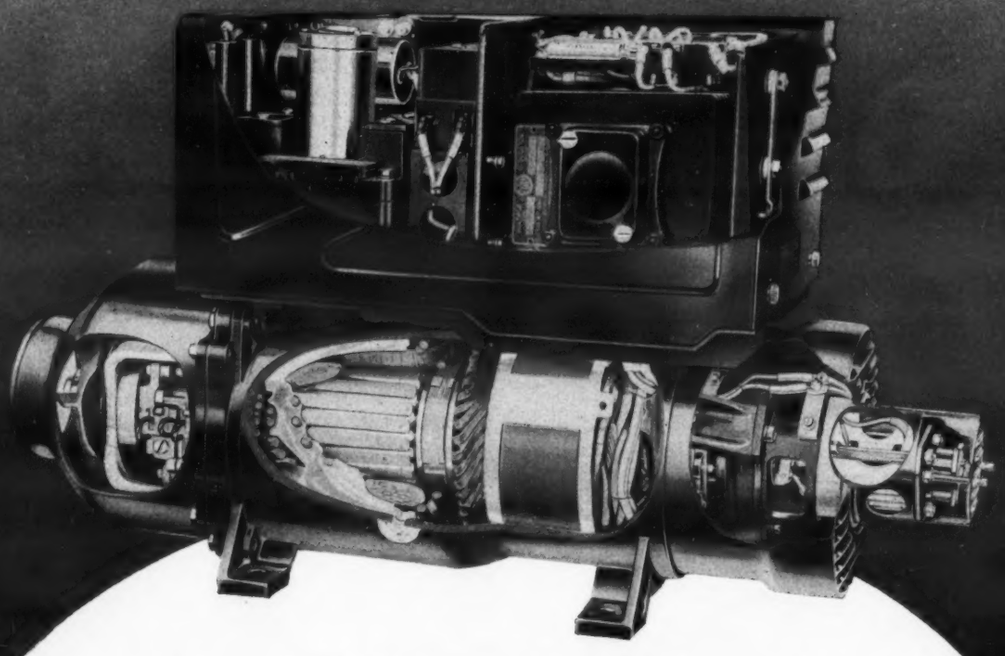
3kVA inverter



used on the Vickers Vanguard



This compact new 3 kVA inverter by Plessey—already ordered for the Vickers Vanguard—is designed to convert general d.c. supply to three-phase alternating current for aircraft instruments and allied equipment. It has an excellent power/weight ratio, features close frequency control and is self-cooled. The control box is mounted integrally with the inverter and houses the starting gear, radio suppression components and the voltage regulator. Design engineers who are interested in this or other Plessey aircraft equipment are invited to request full technical information.

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A Passenger Converts to Jets

By E.K. Barnes, Interavia, Geneva

The appearance of numerous slogans emphasising how distances have been reduced and how small the world has become was one of the first evidences of this Jet Age. As the modern air traveller tends to measure distances purely in terms of time, the fact that the statute mile remains unchanged is forgotten. As I was recently given the opportunity of travelling on the latest addition to the world's jet services I firmly intended to keep this fact in mind. Looking back after the event I must admit that I failed. It is no longer any use telling me the exact number of statute miles, nautical miles or kilometres that separate London and New York; I now think of the distance as 7½ hours.

The place was London Airport, the time 5 p.m. November 24th, and the occasion the departure of the Trans World Airlines Boeing 707 *Intercontinental* on the inaugural service London–New York. An hour prior to the scheduled take-off time Mr. Charles S. Thomas, President of TWA, with a neat sense for the occasion had invited Air Commodore Sir Frank Whittle, the first jet engine pioneer, to christen the aircraft "London Town." By 5 p.m. the 130 passengers were aboard and the aircraft, under the command of Capt. L.R. Hincks, was ready for departure. It was at this moment that a glance at the flight schedule gave my ideas of the distance between London and New York their first set-back. Leave London 5 p.m., the Englishman's traditional tea-time, arrive in New York at 7.30 p.m. in time for dinner and the theatre. New York theatre managements will now be faced with the necessity of advertising their programmes in the English newspapers and opening seat reservation agencies in London. Other impressions followed. The sounds of conversation in the cabin intermingled with music from the relay system. The muffled sound of the engines muted by the cabin insulation. The steep climb after take-off to clear the residential areas surrounding London Airport and reduce the noise problem to the minimum, followed by the levelling off to a more gradual angle of climb to the cruising altitude at 31,000 feet. A point of interest here, the announcement just before take-off that cocktails would be served when cruising altitude was reached, and the cocktails arriving within a matter of minutes of the announcement.

As is to be expected, cocktails were followed by dinner. My compliments to the chef for a superb meal, and to the cabin attendants for the service. Pausing on a domestic note, the cabin aisle of the 707 is wide enough for a trolley to be used to speed up the service. This is a point of some importance because the service of 130 meals presents problems of organisation that would defeat many hotels. One feels that the stewards and hostesses can claim to have crossed the Atlantic on foot.

After dinner–coffee, liqueurs and a glance at the newspapers. Then came the major disappointment of the flight, an announcement from the captain that weather conditions in New York would necessitate landing in Gander. Shortly afterwards a change in engine note indicated that the aircraft was letting down for landing. Gander, cold and with light snow powdering the ground, but after some forty minutes to explore Newfoundland the passengers were recalled to the aircraft. Again the rapid climb and the same rock steady vibrationless flight at cruising altitude. Unfortunately, these conditions did not hold good the whole way to New York. The changing engine note once again heralded the beginning of the descent which was punctuated by periods of considerable turbulence. Although adding to the captain's difficulties in positioning for the landing at Idlewild it also offered a convincing demonstration of the damping qualities of the flexible Boeing wing. Occasional glimpses of neon lights through the gaps in the driving clouds became more frequent, and a fortunate break revealed the glow of the Broadway-Times Square district reflected in the clouds. A long straight approach and the aircraft touched down at Idlewild in driving torrential rain. The inaugural TWA service was completed, but unfortunately the weather decreed that it should not be non-stop. As I walked into the Customs examination hall and prepared to defend my possessions from taxation or confiscation (no A-bombs or luminous alarm clocks), two thoughts came to mind. I had crossed the Atlantic without seeing it once, and it was 9.30 p.m. and too late for the theatre. Standing in the Customs hall I caught sight of Air Commodore Sir Frank Whittle who had also been a passenger on the aircraft he had named earlier in the afternoon. It would have been interesting to know his unspoken thoughts on this modern development of his pioneering work. An aircraft propelled by four engines developed from the principle he devoted so much time to elaborating had just crossed the Atlantic carrying 140 people on board, at a speed which exceeded that of the early jet engined fighters. Few men can have seen a more satisfying example of the development of their work within such a relatively short time.

The return journey some days later followed the general pattern of the outbound flight. Perhaps the most impressive point being that of

The Boeing 707 *Intercontinental* climbs away after take-off.

speed. From leaving New York to passing over London a total time of 5 hours 26 minutes elapsed, while a further hour's flying took the aircraft to Frankfurt and the end of its journey. Again the same quiet vibrationless flight, the superb meals and also the sense that the journey was too brief to be a transatlantic crossing.

During the journey I had the opportunity of talking with the aircraft crew. The first and strongest impression I gained from them was their enthusiasm for jet transport and this aircraft in particular. The crew were all veterans of the days of piston engined operation on both the transatlantic and domestic TWA routes. They were all unanimous in their praise for the handling qualities of the aircraft and the fact that the quieter smoother flight in comparison with piston engined aircraft made their duties far less fatiguing. During the conversation the thought struck me that the recent controversy concerning the maximum age for jets pilots could probably have been resolved if more opinions had been sought from the pilots themselves. On the flight deck of "London Town" the attitude was that the coming of the jet would extend the length of the pilots' active service rather than diminish it by creating arbitrary age limits. The docility of the aircraft combined with greater simplification compared to piston engined aircraft more than outweighed its greater size and speed. Piloting the 707 called for the use of new techniques in handling but, once the transition had been made, the crew viewed the possibility of flying piston engined aircraft again with a certain disfavour. One detail of handling technique struck me in particular. At high speeds any forward movement of the control column will obviously induce negative G forces in the cabin and tend to displace the passengers from their seats. In order to obviate this and to achieve the maximum passenger comfort, any manoeuvres which necessitate a nosedown pitch such as the beginning of a descent are first initiated by going into a turn; this maintains a positive G loading while the nose is pushed down and the aircraft is then rolled out onto the desired heading for the let down. A small point but important in the sense of passenger comfort.

A final comment on the jet age: perhaps its distance shrinking effects are most apparent on the people who are closest to it—the airlines' passenger handling staff. This occurred to me when I overheard a conversation in Frankfurt. A passenger wished to make an intermediate stop in London on the Frankfurt–London–New York service. The weather report for London was unfavourable, and the passenger was obviously considering the likelihood of the aircraft landing at an alternate airport. On enquiring as to the possible alternate landing in the event of London being closed the reply came without hesitation—New York! Perhaps I am not alone in forgetting the statute miles between London and New York.

◆◆

The TWA Flight Training Center

The name Flight Training Center immediately calls to mind the picture of an aerodrome, with hangars, runways, training aircraft and perhaps the remembered smell of burnt fuel to add realism to the scene. In comparison with this mental picture it is difficult at first to understand the sign in the panelled hallway of an eight storey building in the business district of Kansas City, Missouri. The sign identifies the Flight Training Center of Trans World Airlines, and the building houses what might be described as a complete aeronautical college. Opened in September 1957, the Training Center is designed to cover the training and refresher courses for the whole of TWA's flight personnel from captain to cabin attendants. The emphasis, however, is naturally on flight training, and the student body is drawn mainly from the flight deck personnel. At the present moment TWA employs 2,314 flight crew personnel, of which 1,530 are pilots, 683 flight engineers and 101 navigators. In the course of a year each flight crew member attends the center for an average of 40 hours training, which covers both refresher courses and instruction on new techniques and procedures which are being introduced into the airline's operational methods.

The training methods employed lean heavily on visual aids to assist the lecturers in explaining the function of any particular equipment. The use of motion picture-film has also been exploited extensively to achieve the greatest standardization in training. In this field TWA has pioneered the use of films for airport qualification training, and the system has been approved by the Federal Aviation Agency. A library is being assembled of all the airports used on the TWA network, and the films are made by the company's own personnel. A sound commentary on the film points out details of importance to be brought to the pilot's attention and warns of obstructions, special procedures to be observed and any other relevant details. The pilot in training for a particular route is enabled to see all the airports on the route in ideal daylight conditions and to orientate himself in relation to specific landmarks around the airport. In consequence when starting to fly the route as a second pilot he is already familiar with the appearance of each airport and any peculiarities involved in the landing. The film library is maintained under constant revision, and special instructions concerning any particular airport can be amended as required.

This visual training is the keynote of the methods used throughout the training courses and is repeated in many variations. Although films and sound track are used extensively for tuition, the normal lecture forms the mainstay of the training. In this connection, however, considerable time and effort has been devoted to the design and development of animated visual training boards which illustrate the operation of aircraft systems. As distinct from actual flight training for pilots and crews a great deal of training time is required to make a crew member thoroughly conversant with the engineering systems on a particular make of aircraft. This is obviously the first stage of the golden rule "Know your aircraft." Unfortunately the designers of modern commercial aircraft differ in ideas on many constructional details, and the conversion from one type of aircraft to another involves a long and laborious study to become familiar with the operation of the systems, safety devices and emergency procedures which are particular to each make of aircraft.

The use of animated visual training displays which illustrate the various aircraft systems, such as hydraulics, brakes, powered controls and fire extinguishing equipment, enables the crew member to obtain a clear mental picture of the steps required in the operation of a particular system, the safety devices associated with it, and possibly to diagnose any malfunction. By seeing the system working in sequence by means of coloured lights and moving components it is far more simple to understand its functioning than by reading a long technical description.

To cover the training requirements of the TWA crews the center operates the whole year round, but there are peak training intakes in spring and autumn. In the quieter periods of the year opportunities are offered to other companies to take advantage of the training facilities available, and training time has been sold to Qantas, Continental, Ethiopian, Lufthansa and Seaboard & Western Airlines. Time has also been made available to pilots who fly executive aircraft for some of the large American corporations.

Turning from routine training of flight crews, the activity which is foremost in the center's programme at the present moment is the training of personnel for the new jet equipment now entering TWA service in increasing numbers. Here the pattern is repeated—visual training aids illustrating the operation of services on the Boeing 707, together with cutaway and animated jet engine models to illustrate the principles of jet propulsion and engine handling. A working engine model controlled from a replica of the engine control console illustrates the sequence of operations required for engine starting and can be used to demonstrate the various situations that can develop through failure to follow the correct procedures.

Other systems of the Boeing 707 are similarly displayed, the hydraulic systems, flying controls, trim control gear, antiskid braking devices, flaps and landing gear. All these systems can be demonstrated by the lecturer, and the student is able to follow the operations in sequence.

Together with the space allocated to ground school training, two floors of the building are devoted to flight training. This is carried out with the use of flight simulator equipment, and in one department four simulators are used for training on pistoned engined aircraft. The interiors of the simulators are complete replicas of the Lockheed *Constellation* cockpit, and electronic equipment enables the instructors to set up complete flight programmes, radio schedules and en route radio facilities for a flight exercise. At the same time emergencies can be simulated by introducing a variety of incidents such as engine failure, instrument failure and fire emergencies. Apart from any sense of motion, the conditions within the simulator cockpit are realistic to the extreme. Engine noise which varies with throttle and propeller pitch setting helps to emphasise the reality of the training.

On another floor of the building, the Boeing 707 simulator is installed. The equipment, which was developed and produced by Link Aviation, Inc. of Binghamton, N. Y., realistically reproduces all flying conditions from take-off to touchdown and is mounted so as to reproduce cockpit motion if required. By this means realistic handling experience can be obtained in varying rough air conditions. The cockpit windows are unobscured, and a film projected on a wide angle screen in front of the cockpit gives a visual representation of the airport terrain and runway during take-off and landing. Shortly after take-off this scenic representation becomes obscured, simulating a climb into the overcast, and from that point the pilot is compelled to control the simulator by instruments alone. The interior of the simulator cockpit is indistinguishable from the normal Boeing 707 cockpit and provides all the instruments and controls used by the pilot, co-pilot and flight

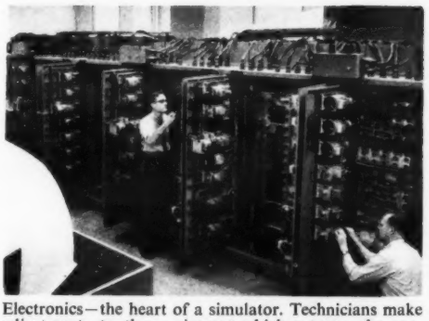
engineer. The instruments are activated by a series of computers and indicate the engine and flight conditions of the simulated flight. The instruments respond to the pilot's use of the controls as well as to external conditions, such as weather and radio signals, which can be introduced by an instructor at the monitoring console. To provide instruction in radio navigation the instructor can also control up to six radio stations which provide either audio or instrument signals to the crew, to simulate en route radio and navigation aids.

The ultimate aid to realism in the use of this simulator is the Link Mark IV Visual System, which provides the pilot with vision on take-offs and landings. Working through a closed circuit television link, the simulator is synchronised with a TV camera mounted on a railed gantry in an adjoining studio. Built on the wall of the studio is a complete model landscape illustrating an airport and surrounding countryside. The TV camera is mounted so as to point towards this landscape at a shallow angle similar to the field of view seen from the cockpit windows of a landing aircraft. By synchronisation of the camera's attitude and speed of travel in relation to the commands given by the simulator computers, the TV camera approaches the airport runway gradually, and the resulting picture is similar to the view seen from an approaching aircraft. The picture is transmitted through the closed circuit link to projection equipment which projects a lifesize picture on a screen in front of the simulator cockpit. Use of this equipment enables a pilot to carry out an ILS landing approach to an airport and, by breaking cloud at a predetermined height, be immediately aware of the accuracy of his instrument approach by his relative position to the runway center line and glide path.

TWA executives in charge of the various phases of training are enthusiastic about the value of simulators as an aid to flying training and in particular as an aid to jet aircraft conversion. From the point of view of cost it is obvious that the simulator is cheaper in operation than the actual aircraft, and many procedures can be learnt satisfactorily on the ground without the waste of valuable aircraft flying time. The standards of realism are such that the student pilots do not regard the simulators as mechanical contrivances which necessitate a special skill to handle but which bear no relationship to actual flying. The modern equipment with its many facilities for recording a pilot's performance and providing him with a personal "checklist" of those points which require special attention is perhaps one of the most valuable contributions of electronics to aviation. Without it the airlines would be faced with vastly increased overheads for training, both in costs and time, and perhaps the coming of the jet age would have been much slower and more hesitant.

With the aid of the animated display board, a lecturer explains the workings of the hydraulic brake system on the Boeing 707 to a group of students.

The jet engine simulator. On the left is the engine control console and instruments from the pilot's position in the cockpit, while on the right is the flight engineer's panel. Operation of the various controls can be followed by the behaviour of the jet engine model in the centre.



Electronics—the heart of a simulator. Technicians make adjustments to the equipment which actuates the controls and instruments of one of the simulators in use at the Flight Training Center.

The Link Mark IV Visual System. Seen here is the model landscape mounted on the studio wall, while the TV camera is mounted on the gantry. As the simulated approach is carried out, the camera tracks along the rails giving a pilot's view of the approach to the airport.

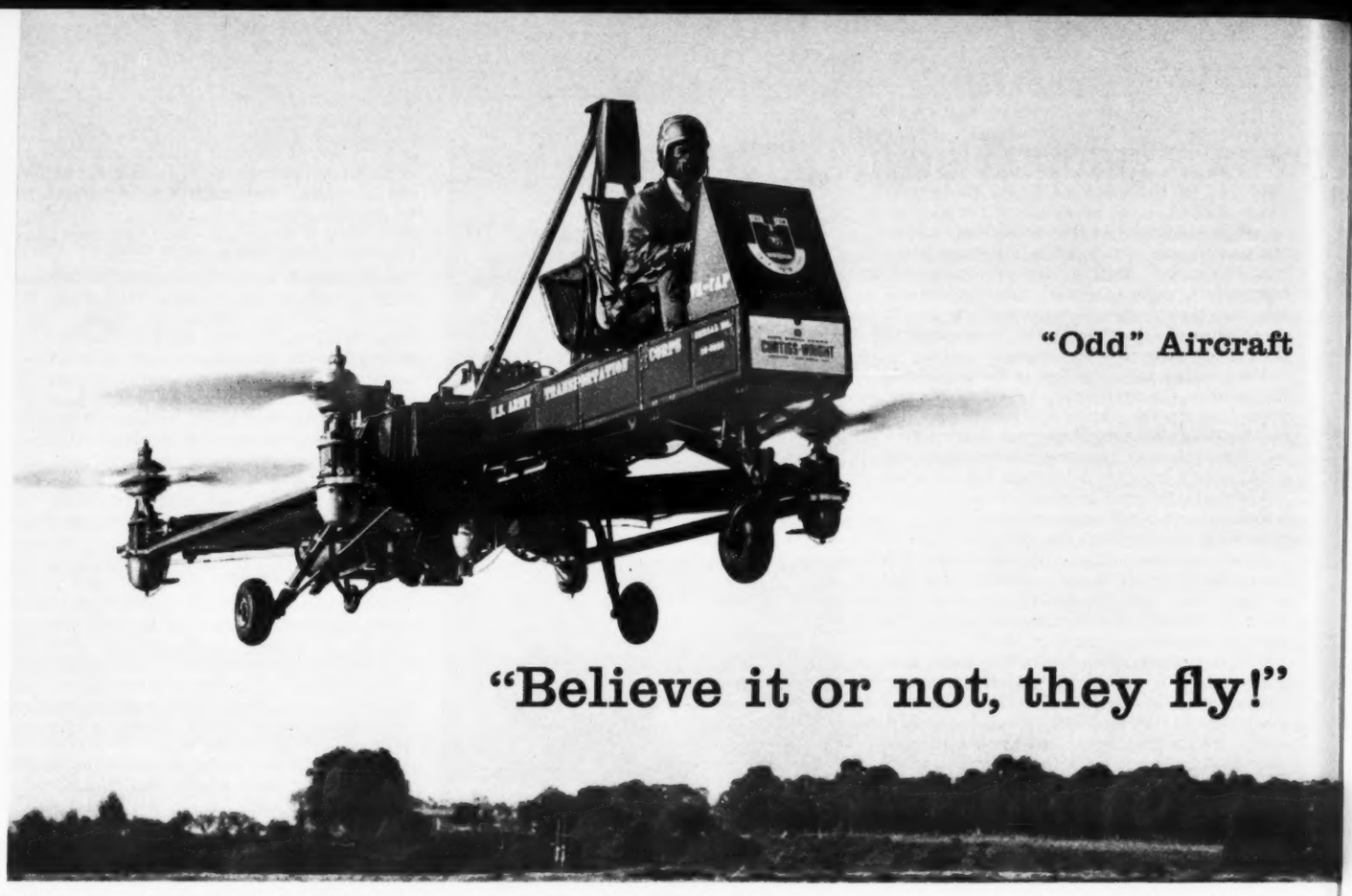
A number of points pertinent to the question of jet conversion arose in conversation with the training staff and instructors of the Flight Training Center. Firstly the time required for experienced pilots to make the conversion is being steadily reduced. This is no question of company policy but the pilots themselves. The large jet aircraft presented a forbidding prospect to the early pioneers who undertook the training programme, and the new machines and new techniques were approached with ultra-caution. After the first students left the Center and returned to line operations they tended to act as disciples of the jet age and point out the virtues of the new aircraft. The result has been very marked in the individual training records maintained at the Center: the time required for conversion, both in terms of actual flying time and in simulator training, is steadily being reduced while the standards of performance are being steadily improved. Possibly the pilots who complete their course in the minimum of time are those married men with a son at school. Surely no man can possess a sterner critic or harder taskmaster than a schoolboy who is impatiently awaiting the day when he can observe nonchalantly to his friends that his father is the captain of a jet airliner.

At present the pilots who are being selected for jet conversion are the senior captains with the maximum of flying and route experience. Normal wastage through retirement on the one hand and steady expansion of the jet equipment will necessitate a steady flow of students through the Flight Training Center for conversion courses for some considerable time to come. The tuition covers a period of 3 weeks with the pupil working a 7-hour 5-day week. Training time on the simulator is now a minimum of 12 hours spread over a period of 7 days, together with a further 12 spent as an observer in the right-hand seat. As for actual flight training on board the aircraft, the average requirement to date based on training records is 21 hours. This period also covers the time required for the Federal Aviation Agency certification check. As the flying training is done in conjunction with time spent as an observer, the pilot will accumulate some 40/50 hours while at school. Following the successful certification flight the pilot returns to line operations and flies one trip as a co-pilot with a check pilot, and then a minimum of five trips as pilot with a check pilot in the right-hand seat. As the pilots who have so far converted onto the 707 have an average of 20 years with the company, it is interesting to reflect on the amount of accumulated flying experience assembled on the flight deck of a TWA jet aircraft.

After seeing the organization required for the training of fully experienced crews on new equipment one final question remains to be answered. How are future crews to be recruited? TWA's answer was straightforward. In this missile age with fewer pilots becoming available who have received their original training in military or naval aviation, the problem is increasing, but TWA anticipates no major shortage on this score. Their requirements are simple. A private pilot with 800 hours flying experience on single engined aircraft alone and with a valid instrument rating fulfils their recruiting standards. With that initial background the company is confident of being able to supply the rest.

To close this account on a personal note, the writer would like to offer his warmest thanks to TWA and its staff on two counts—for the superb service on board the Boeing 707 on two Atlantic crossings and for the assistance received while visiting the installations. ◆◆

"Odd" Aircraft



"Believe it or not, they fly!"

The Santa Barbara Division of Curtiss-Wright developed this VZ-7AP for the U.S. Army's Transportation Research and Engineering Command. Power is supplied by a 425 h.p. Turboméca *Artouste IIB* shaft turbine driving four rotors. The forerunner of future "flying jeeps" and Army trucks weighs roughly 2,400 lb and measures 17 ft in length.

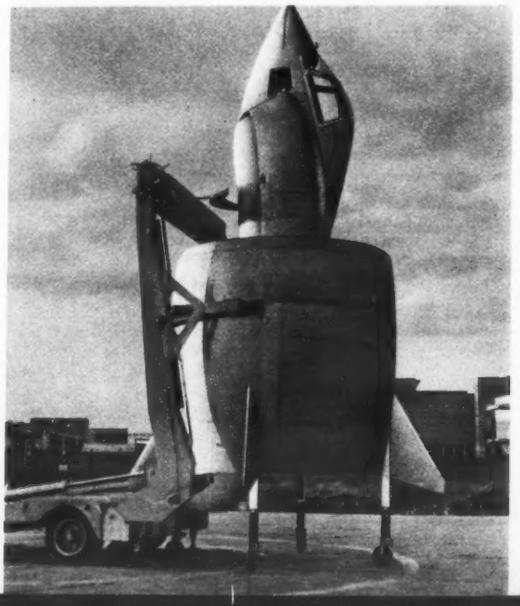
Instead of tilting the whole wing, the Doak 16 experimental VTOL model merely swivels the two ducted propellers at the wing tips. Power comes from an 840 h.p. Lycoming T 53 gas turbine in the fuselage centre.

"Odd aircraft"—there is really no other way of describing those strange forms reminiscent of cubist sculptures, the offspring of new development trends, where rotors, propellers, and control and stabilization surfaces sprout out at the most unexpected places and on whose tiny platforms can often be found a solitary G.I., helmeted and armed for assault, skimming over unknown terrain.

But, joking apart, readers are mistaken if they think the following pages contain a review of "back-yard" contraptions. On the contrary, the aircraft described are all perfectly presentable creations... Take the motor car, for instance. In the not very distant future even the most conservative citizen will have to get used to the idea of

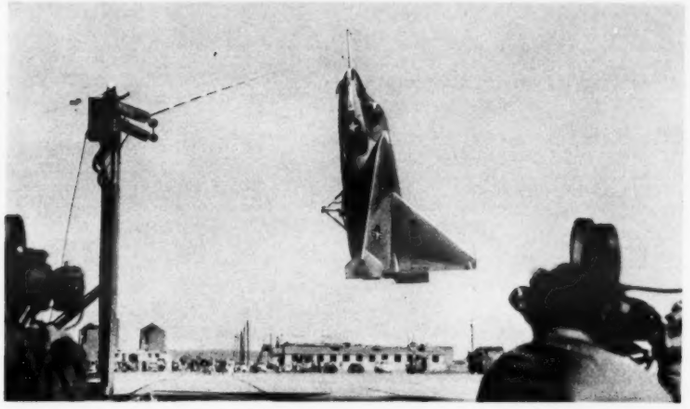
Vertical take-off at all costs, this time with flaps: the Ryan *Vertiplane* shown here forms a transition to the "odd aircraft" which follow.

Another method of vertical take-off: France's Coleopter with SNECMA *Atar* jet, built jointly by Nord-Aviation and SNECMA.



With rotors whirring fore and aft, the Bensen Aircraft Corp.'s B-10 *Prop-Copter* experimental vehicle is powered by two 72 h.p. McCulloch 4318E engines. It would certainly not be everybody's cup of tea to "fly" along at 60 m.p.h. in this shopping basket.

The tilt-wing Vertol 76 (Lycoming T53 engine) takes off vertically. Odd aircraft? . . . yes, just, but it does have a wing like any conventional aircraft.



One of the "tail sitter" family, for which there was a great vogue a few years ago: the Ryan X-13 *Vertijet* (for details of this category of VTOL aircraft see also *Interavia* No. 7, 1958).

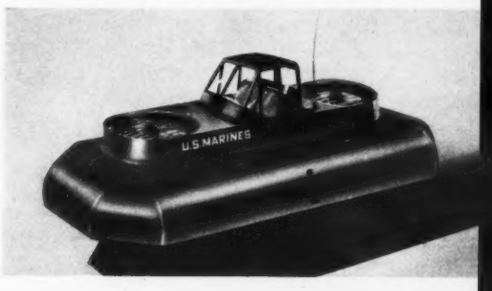
rising into the air in his elegant limousine to avoid nerve-racking traffic jams. This, of course, assumes that traffic jams will not begin all over again fifty feet or so above the thoroughfare. And the driver of a heavy army truck will soon have to supplement his driver's licence by a pilot's certificate.

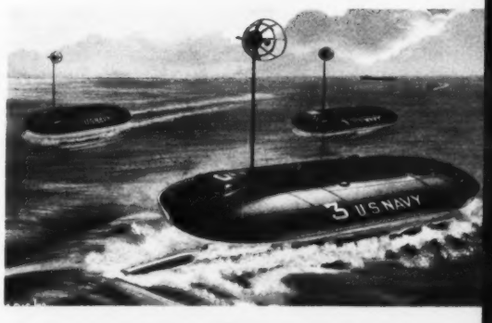
Ground Effects Machines or Hovercraft

Just how seriously industrial and military circles in the USA, Britain and France are taking research on flying platforms, hovercraft and other vertical or short take-off types, is shown by the fact that at least a dozen firms on both sides of the Atlantic are already working on such "odd aircraft," and considerable dollar and sterling credits have been made available for their development.

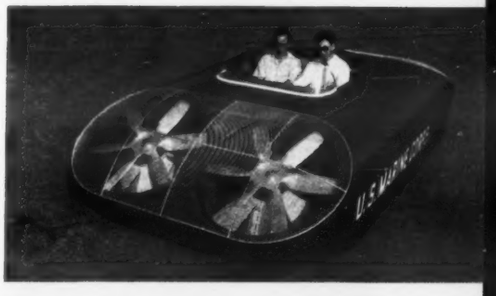
In the USA, apart from a number of research institutes and universities, the U.S. Army Transport Research and Engineering Command (TRECOM) and the Office of Naval Research are the

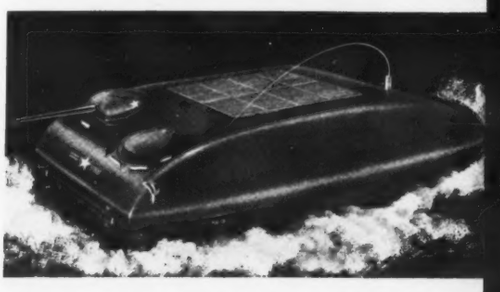
Some typical Ground Effects Machines



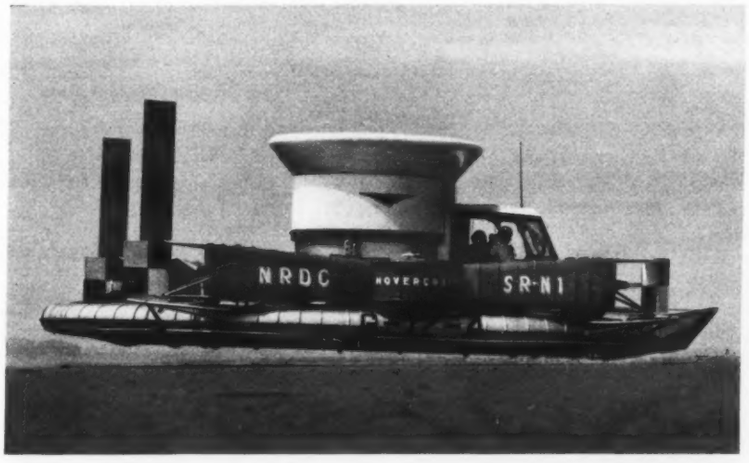


On the other side of the Atlantic National Research Associates Inc., of College Park, Maryland, is working on hover vehicles for the most varied applications, under contract to the Navy and the Marine Corps. Top, a multi-purpose vehicle weighing 1,600 lb and powered by two 40 h.p. Triumph engines. The next picture is a drawing of Navy remote-controlled hover vehicles such as might be used for detecting and destroying enemy submarines. Third from top is the GEM-1, or Ground Effects Machine No. 1, built by National Research Associates. Finally, the lowest picture shows a troop transport on the same propulsion principles, such as could be used for landing assault units.

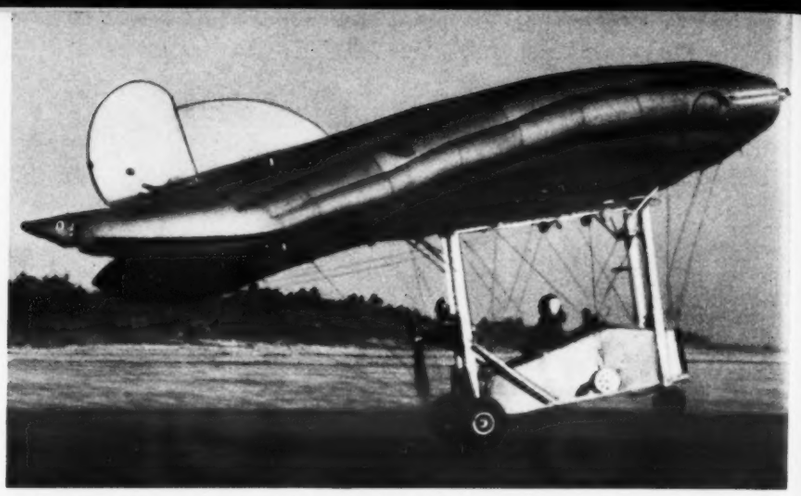




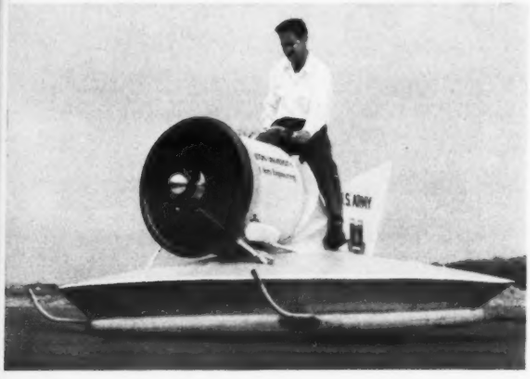
The SR.N1 experimental hovercraft (435 h.p. Alvis *Leonides*) built by Britain's Saunders-Roe, has already been followed by a series of other projects. Considerable importance is attached to this type of vehicle in Britain, as witness the fact that major manufacturers such as the Hawker Siddeley Group, Vickers-Armstrongs and the English Electric Group are seriously interested in its continued development.



Skimmer is the name of this hover vehicle built for the U.S. Navy and now being tested at the David Taylor Model Basin facility.

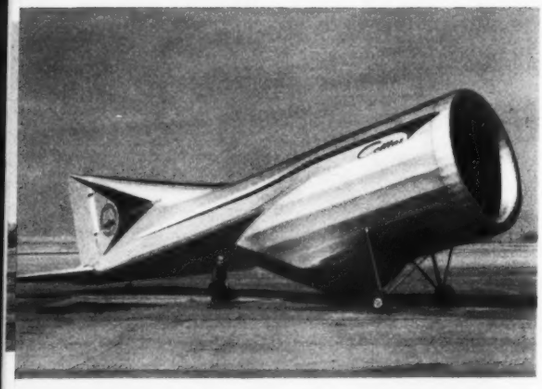


The "Flying Mattress"—or perhaps "Flying Soap Box with Rubber Wings." This extremely simple vehicle is the work of Britain's M.L. Aviation Company.



Flying hobby-horse . . .

This *Flying Scooter* was constructed by staff of Princeton University's Aeronautical Engineering Department, under study contracts from the Army Transportation Research and Engineering Command.



. . . and flying stove pipe

Dr. Alexander M. Lippisch's Aerodyne. Dr. Lippisch has already built and tested a whole series of experimental models for Collins Radio Co., with occasional financial support from the Office of Naval Research.

main organizations interested in the so-called ground effects machines. These two military authorities have awarded contracts to Aerophysics Development Corporation, Bensen, Chrysler Corporation, Curtiss-Wright, Ford, Gyrodyne Company of America, Hiller, Piasecki, Spacetronics Inc., the Aeronautical Engineering Department of Princeton University, etc.

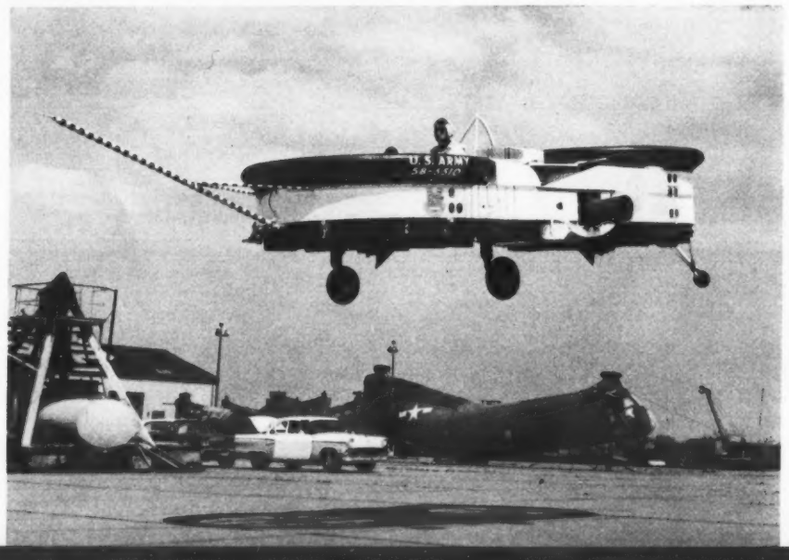
Military interest in GEMs is understandable, as such vehicles, whatever their sizes, are highly suitable for the transport of troops and equipment, or for observation purposes. A soldier can step onto a platform and "hop" over the most difficult obstacles in any terrain. Due to the high noise level of this equipment, however, there would be no question of taking enemy positions by surprise.

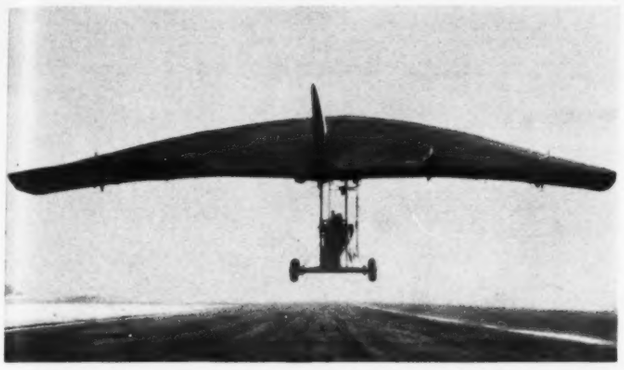
Flying platforms and GEMs have their charms for civilians, too. Thus the SR.N1 hovercraft developed in Great Britain by Saunders-Roe has led to a whole series of further projects, among them plans for a 100-ton cross-channel car ferry and a 400-ton long-range transport vehicle, which, with a relatively modest power rating, could transport payloads up to about 150 tons at speeds of 100 knots and over.

Flying dinghies, flying saucers and flapping wings

"A flying soap-box hanging from a rubber wing..." thus disrespectfully did certain merciless critics speak of the "multi-purpose aircraft" developed by the British firm M. L. Aviation. Hardly more flattering was the opinion expressed by the man in the street on the Goodyear "Inflatoplane." Nevertheless, both firms are in

Piasecki Aircraft Corporation is also engaged in the development of ground effects machines. Left, the VZ-8P experimental vehicle built for the U.S. Army, which has already made hovering tests to altitudes of more than 20 ft. Right, the original version of this vehicle (then known as the Piasecki 59 K). A projected civil version is designated *Sky Car*.





The M.L. Aviation *Utility* (65 h.p. engine) shortly after take-off. Gross weight is roughly 1,000 lb, and despite its clumsy-looking wing the contraption can reach top speeds approaching 60 m.p.h.

Former pilot Dmitri Ilyin, now a school-teacher in Babushkin, near Moscow, created this ornithopter, with 3 h.p. auxiliary motor.

all seriousness pursuing their aim of creating an easily transportable vehicle which, when folded, could be released by parachute and, on inflation, would be suitable for tasks of all kinds.

Flying saucers actually do exist! They are not, however, manned by fully-transistorized robots from a distant planet, but by real flesh-and-blood human beings. Two examples which should be taken seriously are an experimental model, known as *Project Y* or the *Avrocar,* developed by Canada's Avro Aircraft, and the newly-fledged circular-wing X-3 built by Princeton University engineers.

The aircraft curio cabinet would be incomplete without mentioning bird flight enthusiasts. The present article refrains from a final pronouncement on the sense and purpose of this category of aircraft. Here, for once, man's ingenuity appears to fail him; not even the most faithful imitation of the wings of our feathered friends is likely to produce results comparable with bird flight. The British sculptor Emil Hartman and the Soviet school-teacher Dmitri Ilyin have made painful efforts to leave the ground; but what are these compared with the graceful flight of a seagull or swallow?... unless the standards set by ornithopter enthusiasts are somewhat less exacting.

This article began with "odd aircraft" having practically nothing in common with conventional types, and ends with ornithopters, which the writer is inclined to regard with some scepticism. Even here, he would be only too willing to revise his judgment, for... "Let everything that hath wings... take to the air!" ↔

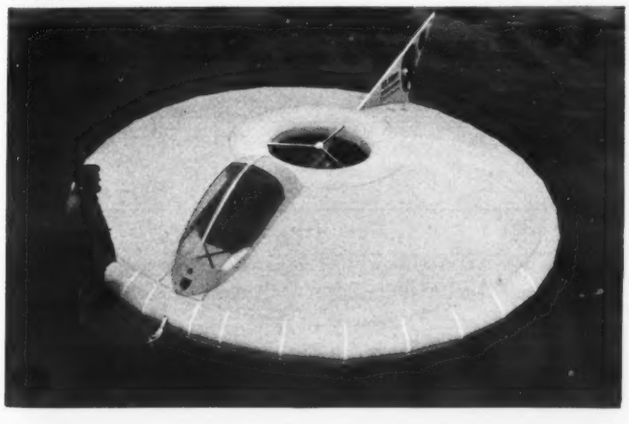
Inflationary trends . . .

Counterpart of the M.L. Aviation *Utility* is Goodyear's *Inflatoplane,* which has been built in a single-seat and a two-seat version. Either a 44 h.p. Nelson or a 65 h.p. McCulloch engine is used.

Back to nature!

Sculptor Emil Hartman, of Chelsea, London, has made several short hops in this ornithopter... but can it compare in grace—or efficiency — with our feathered friends?

A flying saucer from Princeton University's Aeronautical Engineering Department, with a 44 h.p. Nelson H-63B engine to drive the centrally situated horizontal propeller, and a 5 h.p. Power Products light motor to drive the small propeller mounted on the fin.



And real live flying saucers . . . though not from Mars

Avro Aircraft Ltd., of Canada, offers this experimental flying saucer, designated *Project Y* or *Avrocar.* Avro's work is being carried out with financial aid from the United States (both the Army and the Air Force are interested), and it is reported from Toronto that the major part of the flight testing will probably be carried out at NASA's Ames Research Center at Moffett Field, California. First flight was made in early December.

What's in the Air?

General Mazer, Chairman of Nord-Aviation (seated) and J.A.R. Kay, Joint Managing Director of Hawker Siddeley Aviation, recently signed an agreement covering the manufacture and maintenance of the Nord-Aviation CT.41 target drone in Britain.

● **The U.S. Federal Aviation Agency** has approved the Boeing 707-220 for airline operation. Powered by four Pratt & Whitney JT4A-3 jets (15,800 lb thrust each), the 707-220 model has the same dimensions and gross weight as the 707-120, but higher performance. The certification flight test programme covered 65 hours 30 minutes.

● **Spain's airports** recorded a total of 125,292 aircraft movements in 1958. Of these 72,182 were accounted for by scheduled domestic traffic, and 31,218 by scheduled international traffic (Europe 23,741, North Atlantic 1,497, Caribbean 733, South Atlantic 837, Africa 4,410). Total passengers numbered 2,307,636; mail 4,650,000 kg; freight 5,350,000 kg. The busiest airport in Spain was Madrid, with 30,654 aircraft movements and 696,103 passengers; Barcelona had 551,115 passengers and Palma 501,937. Madrid now ranks tenth among European airports. Of the 733,766 passengers who flew to Spain in 1958, 174,618 came from Britain, 115,426 from France, 91,558 from West Germany, 49,962 from Italy and 25,019 from the USA.

British European Airways took delivery on November 16th of the first two of the seven de Havilland Comet 4Bs *on order. Attending the ceremony at Hatfield were (left to right) A. Milward, BEA's Chief Executive, Lord Douglas of Kirtleside, Chairman, and Sir Aubrey Burke, Chairman and Managing Director of The de Havilland Aircraft Company. BEA will be using the* Comet 4Bs *occasionally on a number of European routes during the winter and will put them into regular service in the spring.*

● **The Burroughs Corporation** has been awarded a $35 million USAF contract to produce an airborne radar surveillance system, known as the Airborne Long Range Input. The system is carried by RC-121 reconnaissance aircraft and provides an over-the-sea extension of the SAGE air defence network. Over 50 percent of the contract, which runs for 42 months, will be executed by subcontractors.

● **The Royal Aeronautical Society** has announced that a prize of £5,000 has been offered by Henry Kremer, Chairman and Managing Director of the Microcell Group, for the first successful flight of a man-powered aircraft, designed, built and flown within the British Commonwealth, under conditions to be laid down by the Royal Aeronautical Society.

● **Telefunken** has received a contract from the Italian authorities for two 2-channel Precision Approach Radar equipments for installation at Rome-Fiumicino and Milan-Linate airports. The equipment will be partly constructed under licence by FIAR (Fabbrica Italiana Apparecchi Radio). It will feature circular polarization and a newly-developed display unit with logarithmic distance scale, as well as interscan facilities for glide path and runway extensions. The installations for Fiumicino will enable instrument landings to be made from three different directions. Both equipments will include the new Telefunken AZ-EL antenna and meet U.S. Federal Aviation Agency specifications.

● **The 1960 Vienna International Fair** (March 13th to 20th) will include an air show for the first time. In addition to Austrian manufacturers, seven foreign firms from the United Kingdom, France and the United States have announced their intention of participating.

● **The U.S. Air Force** has abandoned further development of the B-70 *Valkyrie* bomber as a weapons system, but will continue work on the Mach 3 vehicle itself for an initial test flight in 1963. The so-called "reorientation" of the B-70 programme was forced upon the Air Force by severe budgetary pressure; expenditure on the aircraft will fall from a proposed level of $150 million for the current fiscal year to $75 million in fiscal 1961 (commencing July 1st, 1960). North American will now be permitted to recall B-70 subcontracts placed with Boeing, Lockheed and Chance Vought. Although the Bureau of the Budget had

At the annual meeting of Canada's Air Industries and Transport Association in Montreal: Pierre Sevigne, Associate Minister of National Defence, presents Jan Zurakowski (left) with the McKee Trans-Canada Trophy.

A Max Holste MH.153 and a Nord 1110 (picture) powered by a Turboméca Astazou *propeller turbine have been undergoing works tests at Bordes. Fifteen* Astazous *have so far been turned out by Turboméca, and further experimental installations are planned. Similar engines are now being fitted to a Beechcraft* Travel Air *at the SFERMA plant, Bordeaux. Later a Dornier Do 27 is to be converted, likewise a four-engine Potez P.840 business aircraft and small transport.*

The prototype of the new Avian 2-180 gyroplane, built by Avian Industries Ltd., Georgetown, Ontario, satisfactorily completed its ground tests at the end of November. First deliveries of the two-seat craft are due in March 1960.

originally sought to have the B-70 terminated completely, the USAF successfully argued that it should be kept moving at a reduced rate against the possible failure of the major missile programmes or the development of unforeseen military requirements.

● **Turboméca's export business** over the past nine years has totalled 5,000 million francs (approximately $10 million) in direct sales, 750 million francs in licence fees and over 1,000 million francs in indirect sales. Over half this business has accrued to the company over the past three years. Turboméca now has overseas customers in 21 different countries. The company's engines are currently installed in the Fouga *Magister*, Morane-Saulnier *Paris*, the *Djinn* and *Alouette* helicopters, the SO.30P and *Noratlas*, as well as a number of prototypes now under test or development (Breguet 940, Dassault *Communauté*, Max Holste MS.260, Morane-Saulnier *Epervier*, SFERMA PD.18, Max Holste 153, Nord 1110, Beechcraft Travel Air, Sud-Aviation *Voltigeur*, *Alouette III*, *Frelon* and Potez 840).

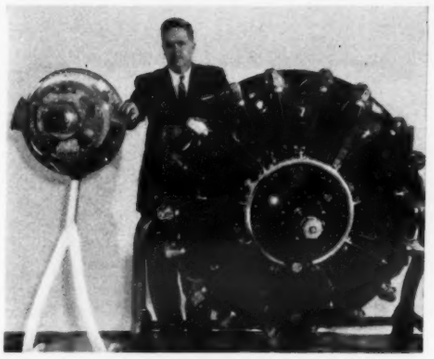
● **Air Trainers Link Division** of General Precision Systems Ltd. is installing an English Electric *Lightning* simulator at an RAF Fighter Command Station in eastern England. Claimed to be the most advanced fighter simulator in Europe, the equipment includes the latest radar fire control and interceptor systems. The prototype is the first of a quantity ordered by the Ministry of Aviation for Fighter Command pilot training.

● **Louis Bonte,** France's Technical and Industrial Director, has revealed that the only new orders covered by the 1960 military aviation estimates will be for a new batch of 100 *Mirage IIIs* and a first production batch of 50 *Mirage IVAs*, each powered by two SNECMA *Super Atars*. Other proposals cover the continued production of the Breguet *Alizé*, Dassault *Etendard IV*, Potez Fouga *Magister* and the Sud-Aviation *Alouette II* and H-34 (Sikorsky licence) helicopters. Prototypes of the Breguet 942 and the Max Holste *Super Broussard* will be developed in conjunction with civil aviation authorities, as well as the Franco-German Transall project. Finally, provision is made for the completion of the *Noratlas* batch which Nord-Aviation had under construction before the order was cancelled.

● **Polish glider pilots** set up 15 national and seven international records during 1959; Poland currently holds 11 of the 32 international records, and a twelfth now awaits homologation by the FAI. In the 1959 season, Polish glider pilots logged a total of 470,000 km cross-country, against 212,000 in 1958.

● **Rolls-Royce Ltd.** has announced new thrust figures for the by-pass *Conway*. The RCo.12 delivers 17,500 lb thrust at sea level, the RCo.15 18,500 lb, and the RCo.42 for the VC.10 and developed DC-8 20,250 lb. The RCo.42's thrust has thus been increased by 9.5 percent; its average specific fuel consumption under cruising conditions has been reduced by 8.6 percent to 0.785 lb/lb/h; by-pass ratio is 0.6. It is also understood that Rolls-Royce will be able to modify the RCo.12 on major overhaul to bring it up to RCo.15 standard; the RCo.15 can likewise be converted to an RCo.42, although this is a more involved procedure. The RCo.42's 20,250-lb thrust is a "guaranteed minimum" and is therefore likely to rise eventually to 21,000 to 22,000 lb.

● **A U.S. Air Force Boeing B-47 Stratojet** bomber has set a new endurance record by remaining in the air for 80 hours 36 minutes, and covering a distance of about 40,000 miles. The B-47 took off from Wright-Patterson AFB, near Dayton, Ohio, at 03:13 hours on November 27th and returned at 11:49 hours on November 30th, 1959. The number of times the aircraft had to refuel in flight was not revealed. The purpose of the exercise was to test a new type of seat which enables crew members to rest even during long periods of operation.



Progress in engine design is demonstrated by Canadian Pratt & Whitney Aircraft President Thor E. Stephenson, who compares a veteran 1944 P & W R1340 Wasp *with the new PT6 free turbine engine. With one-seventh of the frontal area and less than a third the weight of the* Wasp, *the Canadian-designed PT6 delivers 500 s.h.p., compared with the* Wasp's *600 h.p.*

Piper Aircraft Corporation delivered its 50,000th aircraft in mid-November; this means the company has built more civil aircraft than any other manufacturer in the world. This one was an Apache, *seen here being handed over to Merrill Ericson, President of Firwood Manufacturing Company, of Dearborn, Michigan (second from right). Next to him (with hat) is J.W. Miller, Piper General Sales Manager.*

The prototype of the Boeing 720 medium-stage jet has reached the flight test stage. This is the first of eighteen ordered by United Air Lines. Orders have also been received from American Airlines (25) and Irish Air Lines (2). First flight was made on November 23rd. The Boeing 720 is fitted with four Pratt & Whitney JT-3C-7s, each developing 12,000 lb of thrust. It can be equipped to carry 90 to 150 passengers and has a weight of 203,000 lb fully loaded.

The ninetieth Boeing 707 and the first 707-420 Intercontinental *for Deutsche Lufthansa rolled off the Renton assembly line on November 18th, 1959. Lufthansa has ordered five of these aircraft, which are powered by Rolls-Royce* Conway *by-pass engines. The company will take delivery of the first of these at the end of January and plans to open a daily non-stop service Frankfurt–New York (flying time 8 hours) and two weekly services to Chicago via Montreal in April 1960.*

● **Radioplane Division** of Northrop Corporation will produce some 400 RP-76 target drones under a contract signed towards the end of last year. The rocket-powered RP-76 established an altitude record for targets in 1959 when it climbed to 61,800 ft at transonic speeds. It is 8 ft long, has a 5-ft wing span and is powered by a single solid-propellant rocket motor fitted with twin exhaust jets. Laminated fibreglass is used for the airframe.

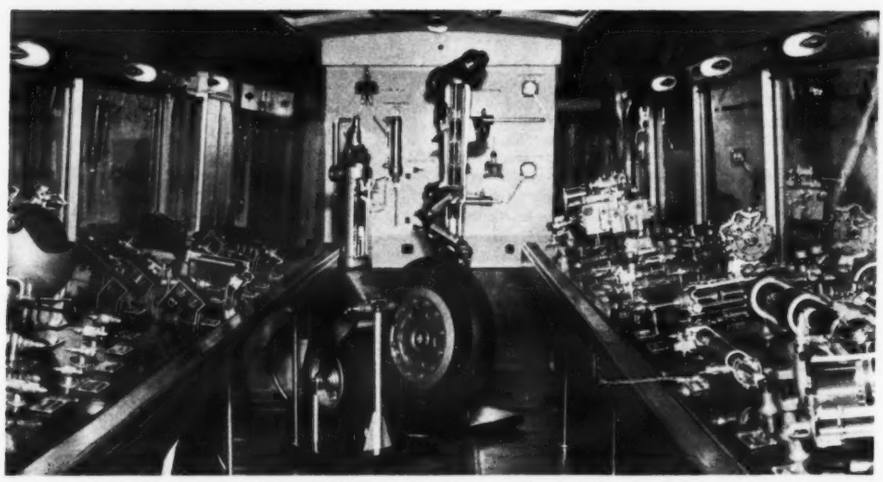
● **The Avro 748 prototype** will be ready to make its first flight early in 1960. The fuselage came out of its jig some weeks ago, and work has since progressed rapidly, the manufacturers announce. Production is spread throughout the Hawker Siddeley works: Sir W. G. Armstrong Whitworth in Coventry is manufacturing the tail units, Hawker Aircraft at Kingston is building the ailerons, Gloster is producing fuselage details and sub-assemblies, and Folland Aircraft is manufacturing the pilots' seats, nose cone and tail cone. Work on the second and third fuselages is also well advanced.

● **The Dassault MD.415 Communauté** (two Turboméca *Bastans*) has completed its works tests and logged 115 flight hours. The last series of flights was made with external loads. The aircraft has since been handed over to the Government Flight Test Centre.

● **VEB Flugzeugwerke Dresden** has finished designing a new twin-jet airliner and has already begun building the prototype, according to agency reports from Berlin. The aircraft, to be known as the Type 155, is said to be a low-wing STOL model with a layout for about 30 passengers.

● **Hindustan Aircraft Ltd.** announces the design and development of a four-seater 190-h.p. high-wing monoplane called *Krishak*, almost exactly one year after the first flight of the company's *Pushpak* light aircraft. The intention is to develop the new model for crop spraying and also as an army observation

Bell Helicopter Corporation has put the 47G-3 model into production, and deliveries are scheduled to begin in March 1960. The Bell 47G-3 will be powered by a Franklin 6VS-335 supercharged engine (constant power rating of 225 h.p. up to an altitude of 15,000 ft). The rotor and rotor head are interchangeable with those of the 47J Ranger, *and other components have been taken over from the 47G-2* Trooper. *The tail boom is 14 inches longer than that of the 47G-2, mainly to compensate for the 2-ft diameter of the tail rotor. The new model is designed for a pilot plus two passengers, and has an equipped weight of 1,539 lb and a gross weight of 2,550 lb. Service ceiling is 23,000 ft, and hovering ceiling within ground effect is 18,000 ft. Maximum cruising speed at low altitude is given as 91 knots, and maximum range as 205 nautical miles.* Right: *A Bell HU-1A was recently converted by Bell Helicopter Corporation to carry six Nord-Aviation Nord SS.11 anti-tank missiles, and subjected to operational testing at the Army Rocket and Guided Missile Agency, Redstone Arsenal, Alabama.*



The Dowty Group Limited recently sent a mobile instructional school with the full range of Dowty equipment used in the Hawker Hunter *fighter to Interlaken, Switzerland. A fourteen-day course of instruction was given to members of the Swiss Air Force, similar to those already held in Belgium, Holland, Sweden, Denmark and Germany (to the 2nd Tactical Air Force). Switzerland has now received over 70 of the 100* Hunters *on order.*

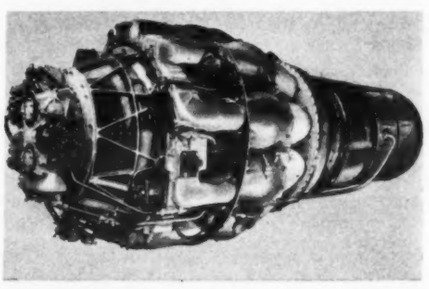
A new facility, named the von Karman Gas Dynamics Facility after the famous aerodynamicist (photo inset), has been opened at the Arnold Engineering Development Center, Tennessee. It comprises six wind tunnels for aerodynamic tests on models of aircraft, missiles and space weapons within an altitude range of from sea level to around 200,000 ft and a velocity range of from 1,000 to more than 12,000 m.p.h. The facility is operated under contract to the U.S. Air Force by ARO, Inc., a subsidiary of Sverdrup & Parcel, Inc.

aircraft. The *Krishak* is at present powered by an American engine, but this will later be replaced by an air-cooled engine designed by P.M. Reddy, Deputy General Manager "Engines", and built in the HAL Aero-Engine Factory. The prototype has been running for some time on the test bench.

● **The Canadair CL-44** four-engine turboprop transport began flight tests on November 15th. During the first flight, which lasted over two hours, an assessment was made of general handling characteristics, such as behaviour at stalling speed, etc. According to ground observers, external noise during taxi and take-off was exceptionally low.

● **The General Electric CJ805-3 jet engine** has completed 5,000 hours of testing. A Douglas XF4D single-jet naval fighter and a USAF twin-jet Douglas RB-66A were used as flying test beds and accounted for over 70 percent of the total test time. Further test flights were made on the prototype Convair 880.

● **Westinghouse** announces a new version of the J34 jet engine, designated the J34-WE-48. It has a different rear layout from earlier versions, resulting in reduced weight and number of parts, and lower maintenance costs. The U.S. Navy has reportedly ordered the new engine to go into production; it will probably



The HS.350 Verdon *turbojet shown here was built in large numbers by France's Hispano-Suiza between 1954 and the end of 1958 and was fitted in particular in the Dassault* Mystère IVA *fighter. This engine, a development of the* Tay, *should be added to the Hispano-Suiza line in the "family tree" published in No.11, 1959. Though the* Verdon *has the same main dimensions as the* Tay, *its take-off thrust is 7,720 lb as against the* Tay's *6,280 lb. The extra power was obtained by a number of refinements which give a higher air mass flow, a higher rev. speed for the turbine rotor and a small increase in the permissible temperatures behind the turbine. Technical date: overall length 104.3 inches, overall diameter 50 inches, installed weight 2,070 lb, take-off thrust 7,720 lb at 11,100 r.p.m. and a maximum exhaust temperature of 720° C, cruising thrust 6,170 lb at 10,500 r.p.m. and 620° C.*

be installed in the Navy's North American T2J-1 trainer.

● **The 16.5-ton Hiller X-18** tilt-wing research transport completed its first test flight—as a conventional aircraft—on November 24th, 1959. The initial aim of the present test programme is to obtain technical data from the X-18 with the wing fixed in near-horizontal positions. First take-off had the wing fixed at about ten degrees to slightly shorten take-off run. The X-18 is scheduled to go through transition and hovering flight after several weeks of tests have accumulated test data from conventional fixed-wing flights at various speeds and altitudes.

● **Capital Airlines' Lockheed Electra** fleet will be equipped with Hamilton Standard 54H60 Hydromatic propellers of 13.5 feet diameter. These propellers use solid aluminium blades with rounded tips. The 54H60 propellers are already in use on KLM Royal Dutch Airlines *Electras*.

● **United States Steel Corporation** has announced a new high-strength steel alloy called *USS STRUX*. The material can be heat-treated to give tensile strengths ranging from 280,000 to 300,000 pounds per square inch.

● **The Hawker P.1127** VTOL/STOL light attack aircraft is advancing well and "shows great promise of meeting RAF needs", the Minister of Aviation states. It is understood that the RAF has already produced a requirement for the P.1127 and that prototypes are being built to Government order. It is possible that the aircraft may be seen at the 1960 SBAC Display.

International Comment

UNITED NATIONS (Colombia)

El alcance siempre mayor de las posibilidades del hombre está ligado al desarrollo de la ciencia electrónica del Siglo XX. De especial interés es el ramo de las Telecomunicaciones que está adquiriendo un profundo valor filosófico, puesto que además de su gran importancia técnica, se está revelando como un mediador de paz y acercamiento entre los pueblos.

Santiago Quijano-Caballero, *Head of the Colombian Delegation to the UIT Conference. Special Telecommunications Advisor to the United Nations.*

DEUTSCHLAND

Vom Beginn der Luftfahrt an war die Funktechnik eine Voraussetzung für den Aufbau eines internationalen Luftverkehrs. Ohne Nachrichtenübermittlung und Funkortung wäre die Entwicklung des Flugwesens in seinem heutigen Umfang nicht möglich gewesen. Inzwischen sind die Fluggeschwindigkeiten derart gewachsen, dass die menschliche Reaktionsfähigkeit oft nicht mehr ausreicht und elektronische Geräte helfen müssen. Die Elektronik arbeitet schneller und zuverlässiger als der Mensch, der sie steuert. Sie ist für das Flugwesen der Zukunft unentbehrlich.

Dr.-Ing. Hans Heyne, *General Manager, Telefunken GmbH.*

FRANCE

L'électronique était déjà devenue inséparable de l'aéronautique. Elle l'était autant au laboratoire de recherches qu'à l'usine de production. Avec l'automatisme, l'électronique a accru son rôle pour devenir l'une des plus fidèles collaboratrices de l'aéronautique. Mais aujourd'hui les engins sont véritablement devenus de l'électronique qui vole. A des vitesses qui défient les réflexes humains, elle seule parviendra à assurer l'avenir de la navigation spatiale.

Dr. Maurice Ponte, *Member of the Advisory Committee for Scientific Research. Vice-President and Managing Director, Compagnie Générale de T.S.F.*

ITALIA

L'elettronica ha assunto un'importanza per l'aviazione che sta alla pari con i mezzi de propulsione e con lo studio delle strutture, essa quindi richiede tutta la dovuta attenzione dei technici e di tutti colore che hanno a cuore lo sviluppo del volo sulla terra e attraverso gli spazii interplanetari.

Lt.-General Carlo Matteini, *President, Società Elettronucleare Nazionale; Professor of Radio Engineering, Rome University.*

NEDERLAND

Het is de aviatiek, en meer nog de astronautiek, die duidelijk de onmisbaarheid toont van de elektronica, daar waar het geldt 's mensen koenste technische dromen tot werkelijkheid te maken. Ook in de andere sektoren der techniek bepaalt de elektronica, met haar nog steeds niet volledig te overziene mogelijkheden, de richting waarin de toekomstige ontwikkeling zich gaat voltrekken.

Ir. P. F. S. Otten,
President, N. V. Philips' Gloeilampen Fabrieken.

UNITED KINGDOM

I welcome the introduction of your new section devoted to electronics. With every day that passes electronics play an increasingly vital part in almost every aspect of flying and I hope that the increased space you propose to give to the subject will help to bring this fact to the attention of all whose business is with aviation.

Mr. F. N. Sutherland, C. B. E.
Managing Director, Marconi's Wireless Telegraph Company Limited.

UNITED STATES

Research and development in electronics today is essential to assure the future. Communication needs require data transmission to augment voice. Potentials of miniaturization must be exploited in automation and computation. Sophistication in fault isolation is improving; airborne navigation must have expanded use of Doppler and inertial systems.

Mr. A. A. Collins,
President, Collins Radio Company.

Electronics

in Aviation and Industry

The dawn of a new decade provides *Interavia* with an opportunity to incorporate a new regular monthly section devoted to electronics in aviation and industry.

Technology waits for no man, and it is only too easy for a society to be supreme today, a pathetic memory tomorrow. To keep on top, an engineer, a manufacturer, an operator, or even a publisher, must constantly be in search of a better product, and better ways to make or present it.

Like any manufacturing company that strives to keep in the lead, a specialized publication must diversify continually. *Interavia* is no exception, and if we assume that our most important editorial function is to give readers the widest possible view of aviation and everything it concerns, then increased coverage of electronics becomes a "must."

Space age technology has given added impetus to research in aviation and astronautics, and practically all key developments in the air during the foreseeable future will depend on electronics in some measure. No aircraft, missile, or space vehicle can be conceived, designed, constructed, or made to fly without this modern science playing a major part somewhere down the line.

A bedfellow of electronics, automation, will eventually influence what we do and how we live; but automation is basically only a method of applying electronics in this new industrial revolution of the twentieth century. The urge behind automation is economy of operation and production in a world that cannot afford to waste time or effort and, as recent evolution of the computer shows, the concept of an entirely automatic factory is no longer an engineering pipedream; in such a factory, man will govern fundamental processes of manufacture and assembly by the simple expedient of pushing buttons.

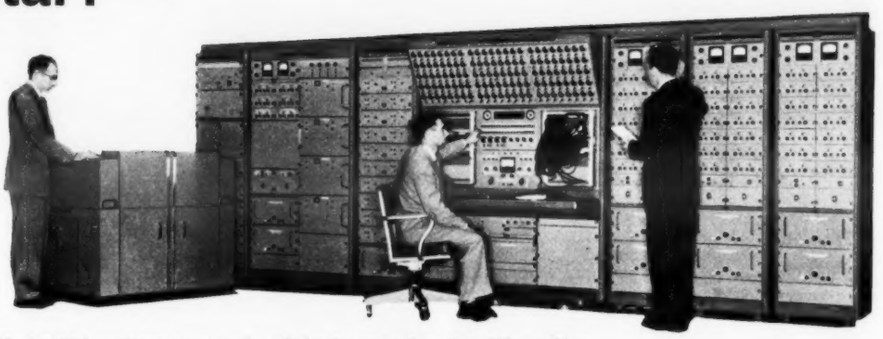
The gradual transition to control by electronics and automation will revolutionize the social and economic framework of civilization. Brainpower will oust brawn; the white coat will replace blue overalls; and a secondary education will no longer be adequate background for a career in industry. So much for the future.

In the present, *Interavia* intends that these few extra editorial pages every month shall focus the attention of readers on new and vitally important techniques. Your comments, criticisms, and suggestions will be welcomed.

The Editors.

Analogue or Digital?

A plain man's guide to computer techniques



Typical U.S. analogue computer installation incorporating about 100 amplifiers.

Although the science of electronics is new, computers of various kinds have a history which extends into antiquity; an early example of the analogue computer was the hour-glass, and a more recent development, the slide-rule (invented by Edmund Wingate in 1672) is still a common item of everyday equipment in engineering.

But however well known the words analogue and digital may be, there is still often confusion and despondency in deciding which type is suitable for which operation, and what the basic operating principles really are.

*

Analogue computers are assemblies of mechanical systems or electronic or electrical circuits, the behaviour of which is analogous to that of, say, a physical system. This analogy is possible because a large number of physical systems can be described by mathematical relationships of some kind, usually differential equations. The analogue computer can be made to obey the same kind of equations.

For example, an electrical system (the analogue computer) and a physical system (flow of heat through a lagged pipe perhaps) can be made to obey the same mathematical rules. If the electrical system incorporates the correct components, both constant and variable, its output (in terms of voltage, for instance) can represent the flow of heat through the physical system, and a recording of this output can be interpreted as the solution of the problem of heat-flow. The operator of the computer must find out enough about the problem that is to be solved to express it in the form of an equation. He must also know enough about the analogue machine to design a circuit that will obey the same equation or a close approximation of it and, in addition, the simulation must be made reasonably accurate over the whole range of the problem.

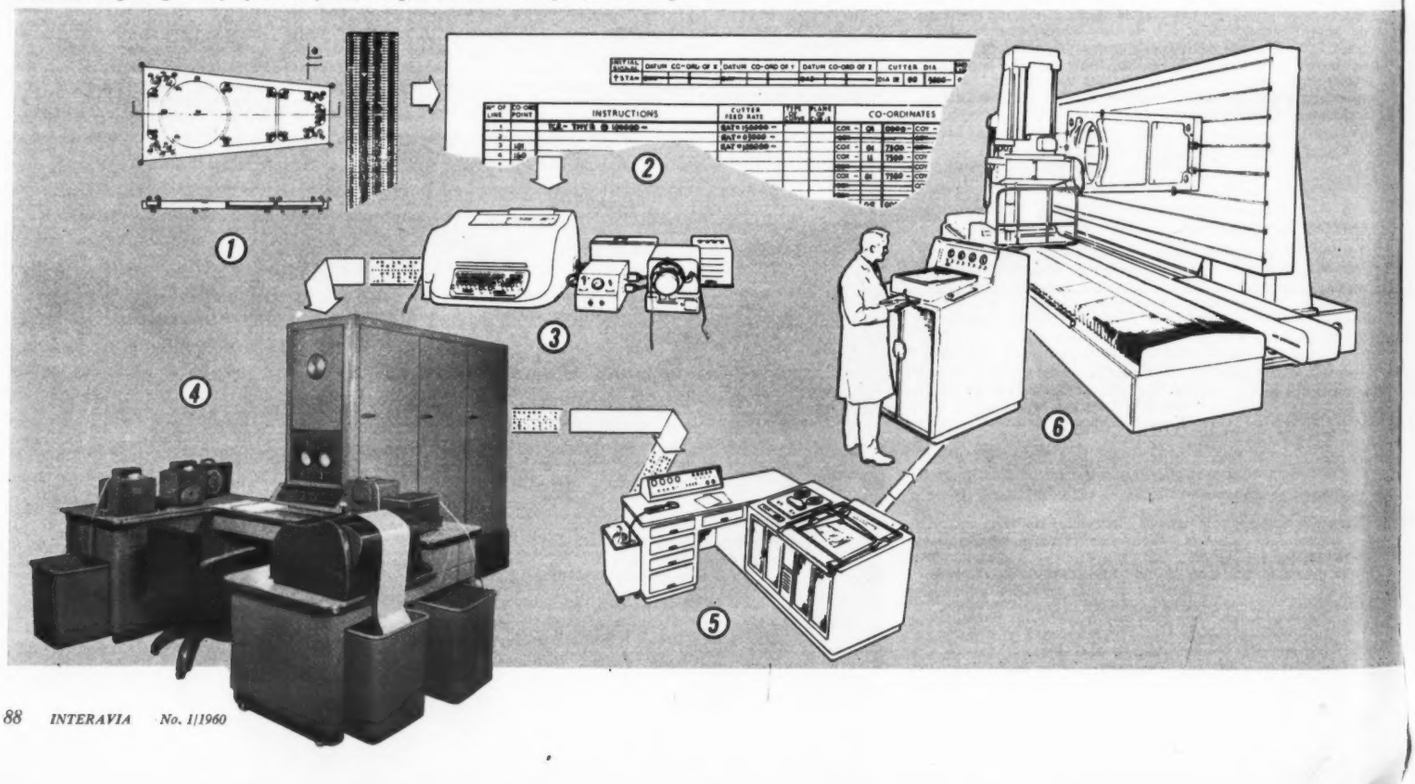
A characteristic difference between analogue and digital computers lies in the fact that analogue machines, if not actually built to perform one type of calculation, still require a considerable effort to change their activity from the solution of one problem to another. Digital calculators, on the other hand, are not limited to a specific purpose and can be used for a variety of problems by the simple expedient of feeding a new programme tape or a set of programme cards.

Analogue computers can yield a very large number of solutions at high speed but they are not as accurate as one might expect, the margin often being as much as 5% and never less than 0.1%.

*

Electronic digital computers, though built initially for mathematical work in science and technology, have been increasingly applied to industrial problems in the past few years and have proved themselves capable of doing routine clerical work ranging from the working out of payrolls to the reservation of seats in aircraft. One of the happy attributes of the digital machine is its accuracy, which is limited only by the amount of time available in which to carry out the calculations.

A Ferranti Pegasus computer installation used to control automatic machining: 1. co-ordinate drawing of component; 2. programming sheet; 3. teleprinter and paper tape check; 4. standard Pegasus general purpose computer; 5. digital differential analyser; 6. a milling machine.



A complete IBM 650 computer with magnetic tapes and ancillary equipment. Swissair uses similar equipment in its wages office.

The digital computer deals with numbers and not physical quantities; a common version is the ordinary cash register, and the first calculator of this type was probably the abacus, which is still used in many countries. As with their analogue brethren, digital calculators are anything but new; Pascal produced a crude form of adding machine in 1642 and Leibniz followed on with the first multiplier about half a century later. More recently, the pater familias of the punched card, Herman Hollerith, designed a revolutionary accounting machine during the 1880's and, finally, the modern concept of the digital computer came into being with the advent of ENIAC (Electronic Numerical Integrator and Calculator) in 1945.

The evolution of the adding machine has culminated in electronic digital computers in which electrical signals are used as the operative discrete signals. The modern radio valve can be in either of two states—conducting or non-conducting—and so it will either allow an electrical signal to pass or prevent it from so doing. Because of this property and for a variety of other reasons, it is convenient to base electronic computers on the binary scale which uses only the numbers 0 and 1 (19 would then be written either as 10011 or 0001/1001, depending on the key).

When an ordinary desk calculator is used, the operator controls the sequence of operations. He supplies the input data, records the result, and he may also have to provide additional information from tables and other sources during the calculation. In the case of electronic computers working at extremely high speeds, human operators are replaced by automatic equipment. But it is unfortunately necessary to provide a store to hold both the numbers which are fed into the machine and the operating instructions. The digital computer can thus be split into a number of basic sections, each of which has a specific function; the input section, which receives raw data and instructions from external sources and converts them into a suitable form for the computer to work on; the store, which memorizes numbers and instructions; the calculator, accomplishing mathematical operations; the control section, which initiates and follows the sequence of operations; and finally the output stage, which presents the results of the calculations in an acceptable form (for the initiated).

An interesting example of a single-purpose digital computer is the Teleregister Corporation seat-reservation unit which was installed some years ago by U.S. airlines using La Guardia airport, New York. The machine does the work of several hundred clerks; previously, an inventory of available space on aircraft was posted on a board and more than two thousand plaques were used to indicate vacancies. Now, an inventory for ten days ahead is kept on two magnetic drums, revolving at more than 1,000 r.p.m. Ticket agents consult the computer in their own offices by pushing a button which is linked to the machine by a direct line; the answer is transmitted back in the same manner and is indicated by a code of lights. Cancellations can, of course, be made just as easily as reservations.

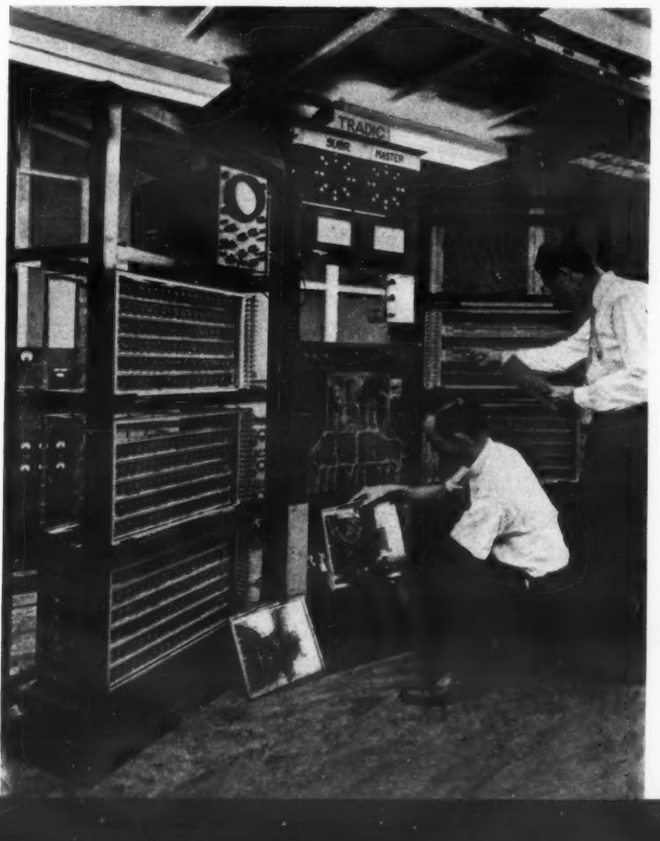
A similar magnetic-drum system is used by a large mail-order firm in the United States. With its aid, ten order clerks can provide up-to-date tallies of 12,000 different items at any time of the day and can deal with about 80,000 orders daily.

*

Broadly speaking, analogue computers are best applied in all cases where speed, and not accuracy, is essential. They find common uses in flight simulation, for solving non-linear ordinary differential equations*, network analysis, and process control. On the other hand, the digital variety is more suitable for complex financial calculations, stress analysis and other problems of aircraft and general engineering design, production planning, operational research, and so forth.

Many different types and sizes of both analogue and digital machines are available on the market. In the *United Kingdom*, small or medium compact computers are being produced by British Tabulating Machine Company, Leo, Powers-Samas, Elliott Bros., the Plessey Company, Solartron, and several other companies. In the *United States*, some of the larger machines are made by Remington Rand, IBM, AiResearch Manufacturing, Nortronics, Philco and many others. The rapidly expanding *French* electronics industry has also designed and manufactured a wide range of computers and some of the most important companies are Compagnie Française Thomson-Houston (CFTH), Compagnie Générale de TSF (CSF), and Société d'Electronique et d'Automatisme (SEA). Needless to say, there are also many other important manufacturers of analogue and digital computers in most of the major countries, including Germany (Siemens, Telefunken, Zuse), Holland (Philips), Italy, Sweden and Switzerland.

There is theoretically no limit to how much computing a computer can accomplish; reading machines, electronic translators, and even radar systems, are all forms of digital or analogue computers. There is, however, a limit to the calculating capacity of the human brain, and the science of electronics has been harnessed to help man to achieve progress that would otherwise have taken decades instead of years. Whether the results obtained with computers appear uncanny or not, the human element is always present somewhere in the operating cycle. Information must be fed to a machine before it can provide an answer, and although electronic circuits may one day be able to reason, true intelligence is still the prerogative of man. ◆◆



A digital computer developed for the U.S. Air Research and Development Command by Bell Telephone Laboratories in cooperation with the Wright Air Development Center. This installation contains nearly 800 transistors and is about half the size of an analogue computer designed to do the same work.

* An ordinary differential equation commonly used in calculating the increase in momentum $(m.dv)$ of a single-stage rocket, in a vacuum free of gravitational force, is expressed as:

$$m.dv + c.dm = 0$$

where c is the exhaust velocity. Thus, for example, the speed at power cut-off (v_e), and at zero initial speed, gives:

$$v_e = c \log_e \frac{m_i}{m_e}$$

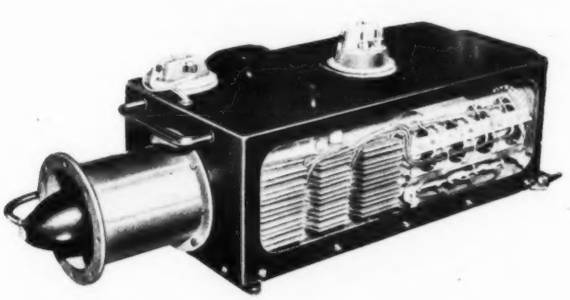
or exhaust velocity times the natural logarithm of the rocket's mass ratio.

What's New in Electronics?

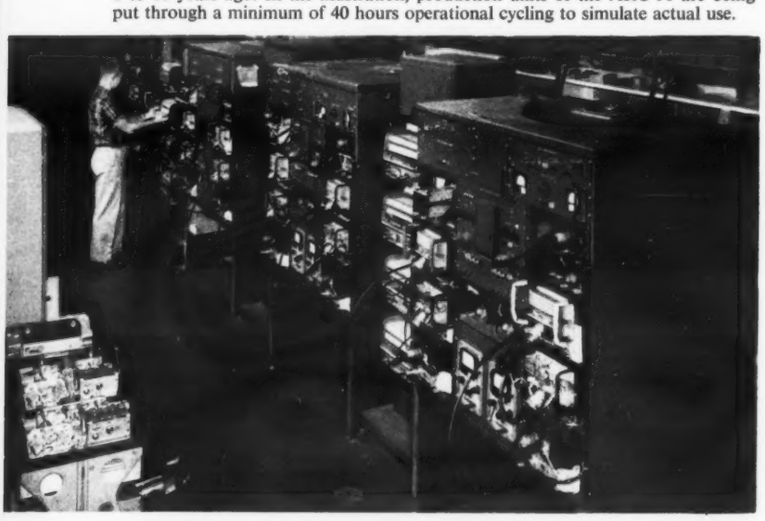
Sperry Gyroscope Co. Great Neck, N.Y. has introduced a lightweight automatic pilot for use in private aircraft. The illustration shows the autopilot control unit fitted in the cockpit of a Cessna *Skyplane* and emphasises the compactness of the installation. The unit provides full three axis control and is equipped with heading, altitude and glide path locks. Total weight of the equipment is 26 pounds (12 kg).

Tamar Electronics, Inc., Santa Monica, Calif., has just announced the new navigation instrument designated Azimuth Indicator, Model Type TIA-1. The unit is a high precision autosyn receiver fitted with a double-ended pointer, displaying both bearing and reciprocal, and an azimuth dial. The dial is rotatable 360° in either direction so that any desired heading reference angle can be set without disturbing the pointer indicator. The instrument operates from either 115 volts AC or 150 volts DC with a current consumption of approximately 20 milliamperes.

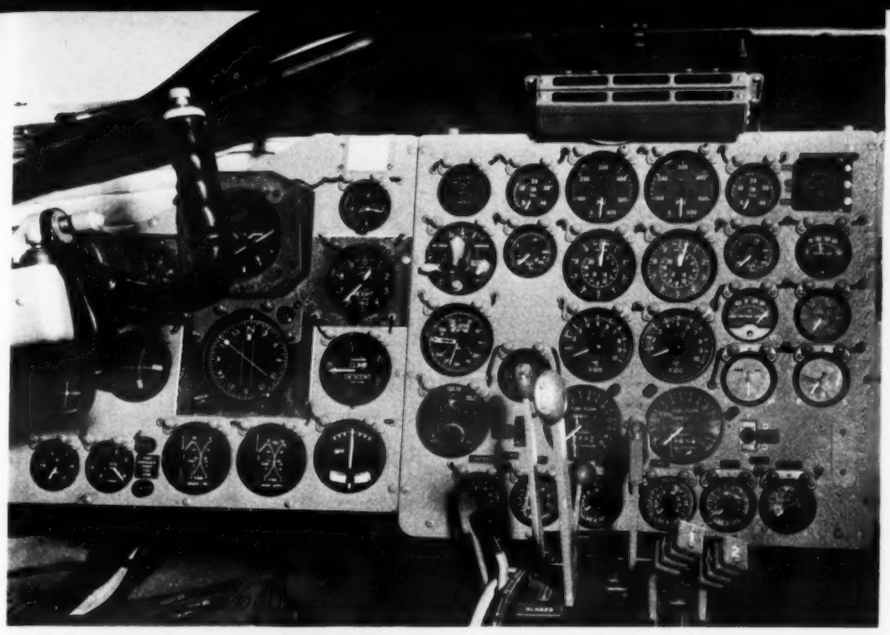
The Plessey Company, Ilford, England, has recently produced the aircraft transformer-rectifier illustrated here. Output is 25 volts DC from a three-phase 200 volt 320–500 c.p.s. supply. The unit is designed for horizontal mounting, and a cooling fan is mounted integrally with the cover. The unit can be used in regulated or non-regulated systems and can withstand a 40 percent overload for two minutes without excessive temperature rise. In the event of fan failure it will maintain 25 percent output without overheating. Weight is 54 pounds and service life 2,000 hours between inspections.



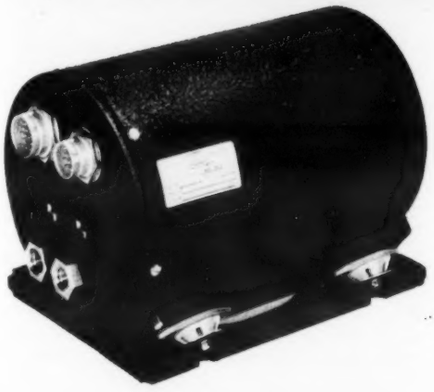
Collins Radio Co., Cedar Rapids, Iowa, have achieved a ninefold improvement in reliability performance with the ARC-58 HF, *Single Sideband Communication System.* This new transceiver was developed by Collins for the USAF and has been maintaining a mean time between failure (MTBF) record of 160 hours. This represents an improvement factor of about 9 in comparison to equipment produced 6 to 10 years ago. In the illustration, production units of the ARC-58 are being put through a minimum of 40 hours operational cycling to simulate actual use.



Minneapolis-Honeywell Regulator Co. Datamatic Division, Boston, Mass., exhibited a new high-speed magnetic tape drive at the Ninth Joint Eastern Computer Conference in Boston. The unit is capable of reading or recording 96,000 decimal digits per second, and an all-vacuum drive in place of a mechanical drive is expected to virtually eliminate damage to magnetic tapes. This will considerably prolong the permanence of valuable records that have been reduced to computer language on tape. The drive will be used with the new Honeywell 800 computer which will be available in 1960.

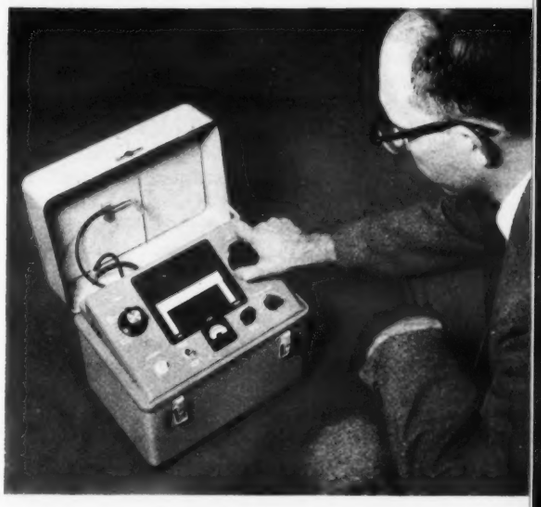


● **Sperry Gyroscope Co. Ltd., Brentford, England,** has supplied the integrated Flight Director and automatic pilot system for the Handley Page *Dart Herald*. The Sperry instrumentation can be seen in this photograph of the *Herald* cockpit. Above the Relative Bearing indicator (left of throttles) is the Sperry *Zero Reader* selector/control panel and below is the combined *Zero Reader/Gyropilot* indicator unit which replaces the standard pilot's control unit for the AL. 30 *Gyropilot*. Forward of the control column are the *Horizon Gyro* and the *Gyrosyn Unit* and to the left the *Zero Reader* flight director indicator. Installed weight of the equipment is 30 pounds and it enables branchline operators to adopt main-line standards of instrumentation and control without needless sacrifice of space and payload.



● **Servomechanisms, Inc. Hawthorn, Calif.** has recently developed a miniature true airspeed computer termed MINITAS. The computer consists of an extremely sensitive and accurate force balance Mach transducer, a passive resistance (damping) network and a follow-up servo. The weight of the instrument is 6½ pounds, and it can be applied in any one of three true airspeed operating ranges to satisfy the requirements for high speed aircraft, patrol planes, helicopters and missiles.

● **Collins Radio Co.** introduced the 476X-1 ATC *Transponder Test Set* at the Airlines Electronic Engineering Committee meeting held in Dallas, Texas. The unit is portable with a self-contained power source for flight line checks of ATC transponder installations. The test equipment simulates the ground interrogator by triggering the transponder and analysing the reply pulsation. The test can be made either by direct connection or radiation, and the unit is designed to enable one man to perform the complete test of transponder receiver sensitivity, transmitter power output, frequency, pulse coding, pulse spacing and operation on all interrogation modes. ▶



● **NATO Radar Station.** The hoisting of the West German flag marks the take-over of the Regensburg early warning radar station. This is the first such station to be manned by West German forces within the framework of NATO.

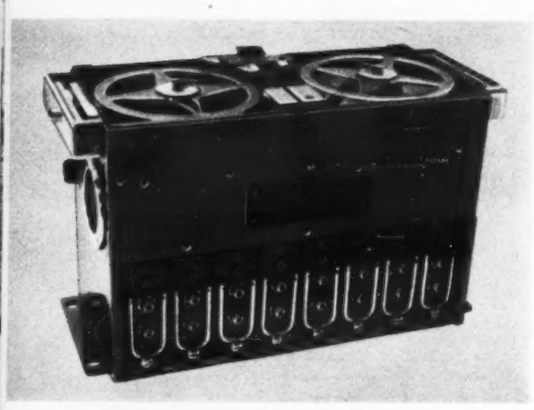
● **Sperry Gyroscope Co, Great Neck, N.Y.** was named in 1958 as the system manager of the programme to design, develop, manufacture, install and test the AN/FPS-35 radar illustrated here. This air search radar is part of a network which is being developed for the defense of the USA. The radar feeds target position information to computers which calculate the interception data for missile weapon systems.

Midas, A Flight Data Recorder

The first items of flight data recording equipment were undoubtedly designed to supplement the test pilots' kneepad and stopwatch, and were used during the flight testing of prototype aircraft. The equipment was perhaps only capable of recording a single channel of information on the aircraft's behaviour, but its chief value was that it produced a permanent record of any particular test.

The development of recording techniques has greatly extended its capabilities today, and flight data recorders are not only used extensively in all flight testing programmes, but have also become widespread in commercial aviation.

Representative of the modern routine flight data recording system is the MIDAS equipment designed and manufactured by Royston Instruments Ltd., Byfleet, England. The basic function of this system is to provide a complete and permanent record of every important operating parameter throughout the life of an aircraft, so that repair and maintenance can be carried out without loss of time in diagnosis of faults, damage or fatigue. The MIDAS system uses magnetic tape as the recording medium, and the airborne recorder has seven separate channels in parallel, one of which is normally reserved for coding information such as GMT, flight number, aircraft identifications, etc. Six channels, each with a very high sampling rate, are thus available for recording data, and a sequential time switching device allows any number of parameters to share each channel. This channel sharing is obviously achieved with a proportionate decrease in the sampling rate.



The Model M24/7 Miniature Flight Recorder; this version is battery operated from a 24 volt supply and the illustration shows the accessibility of the plug-in units.

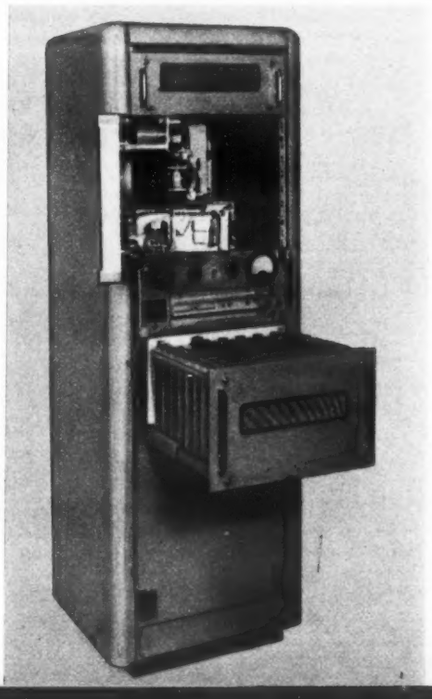
The three methods of recording on magnetic tape, frequency modulation, pulse width modulation and digital recording, each offer advantages and disadvantages which are particular to the individual system. Comparative accuracy figures show the frequency modulation system to have a recording accuracy of 1% and a frequency response of 10 kc/s at a maximum tape speed of 100 inches per sec, while the digital system offers 0.5% recording accuracy but only 100 c/s at the same speed. The MIDAS system has been designed to combine the advantages of these two systems by recording an FM carrier which, on play back, is demodulated direct into digital form from a master time signal with complete overall error cancellation. At the same time it is simultaneously produced in analogue form. This gives an accuracy percentage of 0.25 to 0.5 and 10 kc/s maximum frequency response.

The flexibility of this design is such that it can deal with any coding, either FM, PWM, digital or direct recording, so that all forms of data handling are present in one equipment. The recorders use a separate plug-in electronic brick unit for each channel, and the type of recording system can be altered by interchange of these units. A further feature of the recording unit is the design of the tape transport system to reduce tape speed variations to the minimum and to withstand the effects of "G" and vibration.

Although the recorder itself is a completely standard unit, the multi-way time switch is adapted to the wiring system of each aircraft. The switch has to be installed at a convenient and accessible junction but, if necessary, the recorder can be placed in the tail of the aircraft and connected to the time switch by ten-way cable.

The switch determines the total number of parameters to be sampled and the sampling rate. The minimum sampling rate for each parameter is once in every five seconds but this frequency can be doubled or trebled by parallelling sections of the switch at discrete intervals so that signals will be sampled two or three times at each revolution of the switch. It is therefore possible to sample up to a maximum of three hundred channels at intervals of five seconds.

The Model HP/7 Playback equipment. This unit is typical of the machine that would be used in a maintenance base for analysis of flight records.



The tape spools provide a maximum recording capacity of 160 hours and are loaded in a specially designed cassette which can be ejected automatically on impact if crash data recording is required. To avoid useless expenditure on time and labour, the tape is normally played back at 100 times the recording speed, so that one playback unit can handle records from a whole fleet of aircraft.

A standard MIDAS playback unit is used to reproduce the six basic signal channels together with the time code channel. The six data signal channels are then fed into an electronic decoding switch which separates the original parameters into a maximum of 300 individual outputs; these are then fed into a patch panel unit which routes each parameter to a suitable computing network and thence to a read-out system. The patch panel is interconnected in such a way that the connections match the wiring of the time-sharing switch installed in the aircraft.

A separate automatic unit can be used in conjunction with the playback installation to analyse all data recorded. With this system, human labour in data reading and conversion is eliminated but human judgment in selection of what are and are not the data required, is retained. In analysing data recorded during normal flight, it is normally sufficient to detect anomalies and register the time at which they occurred. A graphic waveform system is then used to reproduce any part of a selected channel so that the important part of the recording can be examined in greater detail. For some parameters it is sufficient to know how many times a reading exceeds a normal predetermined standard and, in this case, the read-out consists of an automatically typed record of the nature of the anomaly recorded against time.

For engine wear records, a factor is automatically computed by taking into account pressure ratio, engine r. p. m., jet pipe temperature, and so on, and which can be used to produce at the end of the recording a figure representing the total wear of the engine during the period that the recording was made.

The new and simpler version of the original MIDAS playback unit has been developed to speed up aircraft maintenance and turn-round without a full analysis being necessary. At the end of a flight during which trouble has occurred, maintenance staff remove the cassette and rewind the tape to a point just prior to the time that the pilot reported a defect. The record is than replayed in a simplified playback unit, and simulated readings of the aircraft instruments are reproduced for the benefit of the ground engineer, who thus has a complete and accurate picture upon which to base his diagnosis.

The MIDAS system as a whole has the signal advantage of being a compact and accurate method of maintaining permanent records throughout the operational life of an aircraft. Apart from the considerable saving in time and labour, data recording on magnetic tape contributes to safety in flight, to more economical use of aircraft, and to research and development of better aircraft equipment. ↔

SFIM MANUFACTURES THE "HEART" OF THE MIRAGE III

SFIM (Société de Fabrication d'Instruments de Mesure) was founded in 1947 under the sponsorship of the Brétigny Flight Test Centre with the aim of procuring vital flight test equipment for government engineers. This led to the creation of measuring instruments and photographic equipment for recording flight parameters, allowing aircraft performance to be monitored.

Since 1952 the technical success of these instruments has enabled SFIM to design airborne equipment such as electrical horizons, gyromagnetic compasses, oxygen regulators and ADFs.

This new, steadily growing branch is now embarking on the manufacture under BEZU licence of the C.V.151 twin-gyroscope flight director, a key instrument in the Mirage III's weapons system.

Parallel with this, SFIM's research and development division has turned its energies to solving new problems in the navigation, pilotage and stabilization of helicopters, fixed-wing aircraft and missiles. Noteworthy developments are floating integrating gyroscopes for inertial navigation, high-sensitivity miniaturized gyrometers for measuring angular velocity, and transmitter/receiver systems for telemetering aircraft or missile flight parameters.

SFIM's activities are rounded off by a new department, set up in collaboration with Société SERGOT to serve present-day technical requirements in the fields of atomic energy and industrial measurements; SFIM's four divisions are at your service to discuss all your problems and find the best solution.

Research and Development

Instrumentation

Radio-electric direction finding

Pilotage, navigation and stabilization of aircraft and missiles

Flight Tests

Photographic recording equipment for civil and military aircraft

Sensors

Radio telemetry for aircraft and missiles

Gyrometers

Airborne Equipment

Gyro-compasses

ADFs

Oxygen regulators

Stall warning indicators

Twin-gyroscope flight directors

Industrial Measuring Equipment

Micrometers

Temperature regulators

Atomic energy sensing devices

Digital computers

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■ Nine Boeing 707, Douglas DC-8 and Lockheed Electra flight simulators, designed and built by Link, are regularly "flying" as much as 20 hours per day, six days per week. Availability exceeds 95%.

■ Eight Link jet engine trainers are regularly achieving utilization rates of 98 to 99%.

■ Additional Link flight simulators, including Convair 880 and Boeing 720, are scheduled for delivery in 1960.

Douglas Aircraft Corporation and the following airlines have ordered, or are now using, Link Flight or Jet Engine Simulators :

UNITED · TWA · QANTAS · EASTERN · BOAC · SAS KLM · CONTINENTAL · PAN-AMERICAN · SABENA TRANS-CANADA · JAPAN AIR LINES · ALITALIA NATIONAL · DELTA

** As of December 1, 1959 !*

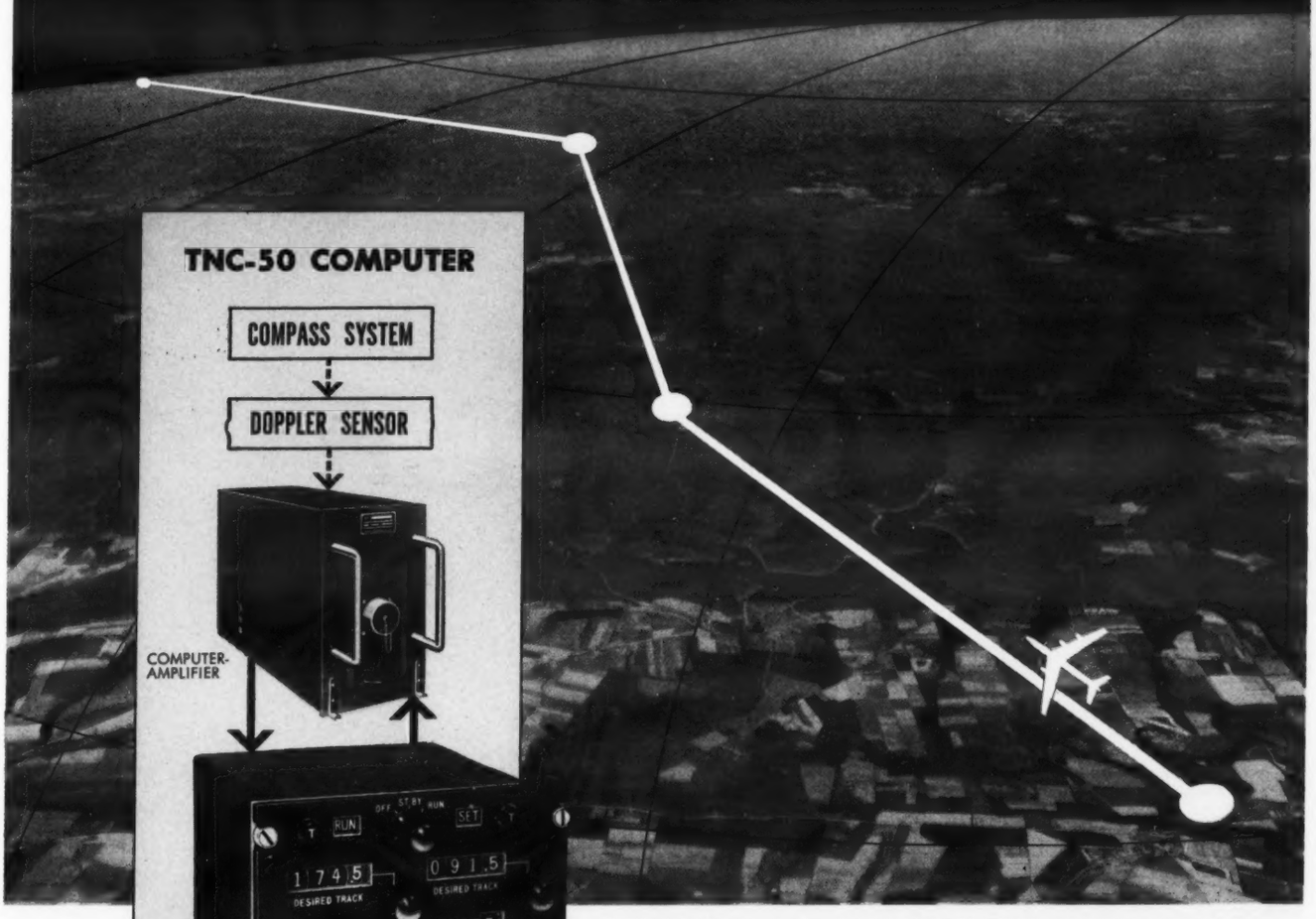
LINK DIVISION

GENERAL PRECISION INC.

Binghamton, New York

GPL track navigation computer TNC-50

continuous readings of distance to go
and distance off track...



TNC-50, GPL's new Track Navigation Computer, provides direct outputs of distance to destination and distance left or right of track. Designed to function with ARINC and other Doppler sensors, and any modern aircraft heading reference, the TNC-50 provides additional outputs for flight directors, autopilots, and attachments.

REALISTIC APPROACH: Utilizing the concept that a flight plan is composed of one or more segments, the TNC-50 provides continuous progress displays of ***distance*** and ***deviation*** along these segments, thereby eliminating complex latitude-longitude instrumentation.

THE RESULT: a compact, accurate computer providing continuous visual and command information to the pilot, and steering information to the automatic flight controls. Write for further data on the TNC-50 and GPL's new ARINC Doppler sensor, RADAN® 500.

GPL DIVISION

GENERAL PRECISION INC.

PLEASANTVILLE, NEW YORK

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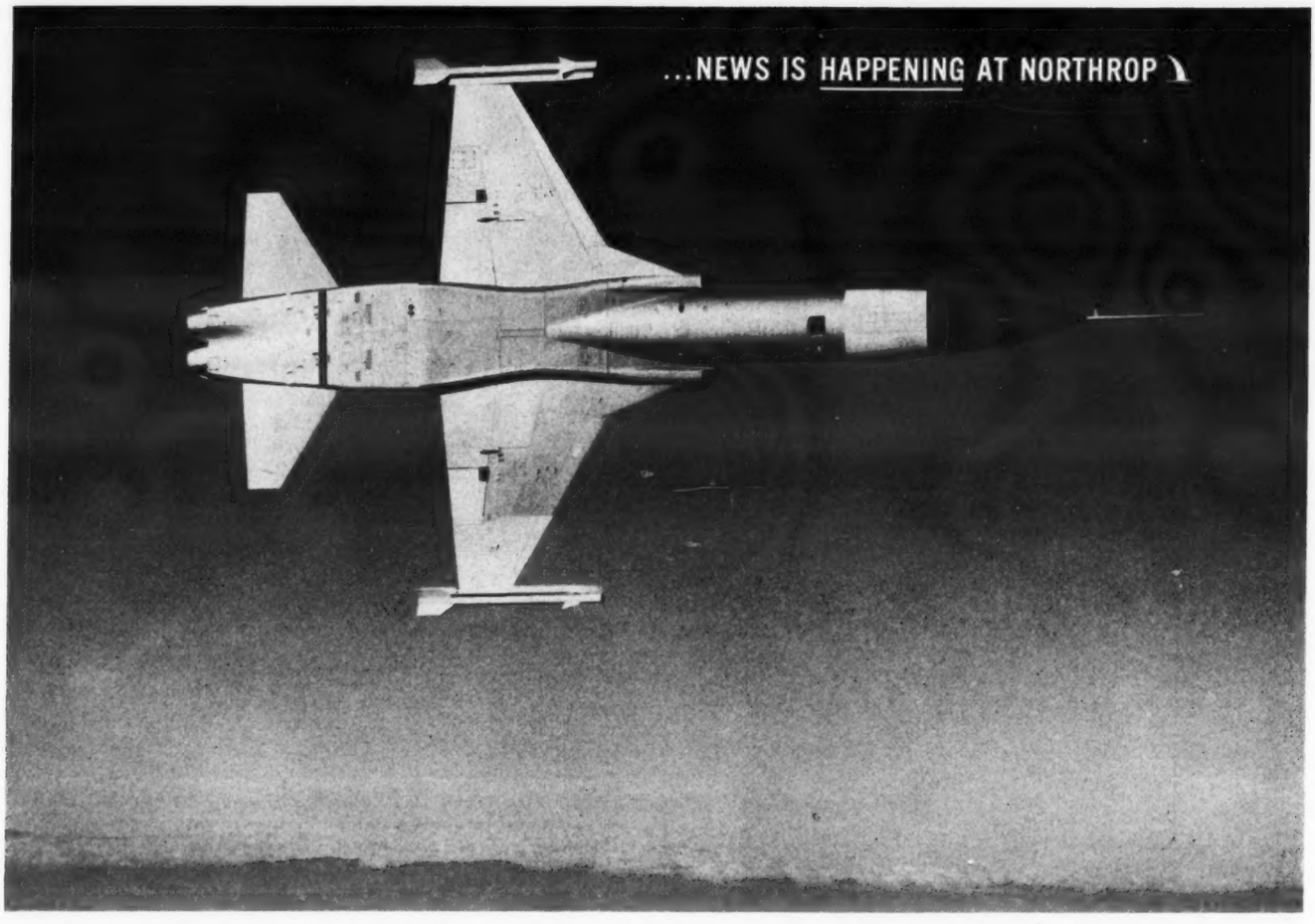

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NORTHROP INTERNATIONAL

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Engines for VTOL Vehicles

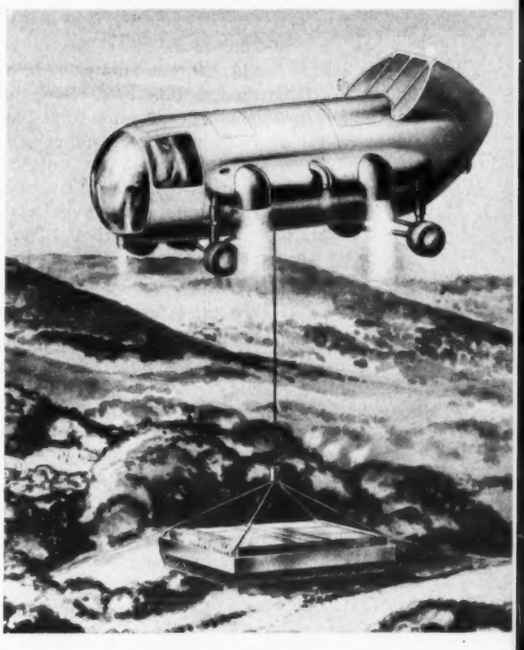
STOL and VTOL aircraft, such as are demanded by the military services for the next generation of manned flying weapons carriers, require special powerplants. The development trends already discernible were discussed recently (December 16th, 1959) by Dr. S. G. Hooker, Technical Director (Aero) of Bristol Siddeley Engines Limited, in his James Clayton Lecture to the Institution of Mechanical Engineers in London. He stressed particularly that the BE.53 ducted fan engine developed by Bristol Siddeley is well suited for VTOL equipment, since it can supply both lift and forward propulsion and has a very high power/weight ratio. Other points from his lecture were as follows:

VTOL aircraft can be divided into two categories, single-seat models and larger vehicles. Whereas a single-seat machine may have only one engine, larger equipment always needs several power units. In the former case the one engine must provide both lift for take-off and landing, and forward thrust for normal flight; this means that the exhaust jet must be deflected either downwards (for take-off and landing) or rearwards (for forward flight), or to any required intermediate position (combination of lift and forward propulsion).

Engines of this kind could be mounted in the aircraft in conventional manner, so that the exhaust jet can always be directed rearwards for conventional take-off and landing. Engine test runs and taxying could also be carried out in the conventional manner, thus avoiding any danger of erosion of the runway or of debris blocking the engine. Finally the aircraft could first be accelerated with the jet directed rearwards and then take off steeply with jet deflected (for short take-off).

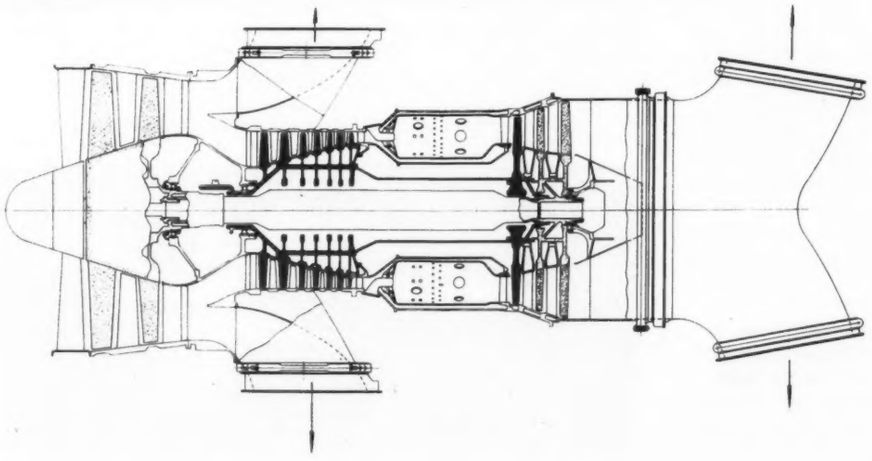
For transport aircraft, on the other hand, a multiple engine installation is required. Since the total thrust needed for vertical take-off is at least equal to the weight of the aircraft, all engines must be capable of giving their full thrust in the form of lift. Once the aircraft has reached its normal flying altitude, most of the engines could be shut off, as the cruising thrust required is normally only about one tenth of the aircraft weight. These particular engines, therefore, can be specialized lift units, but must have minimum weight to keep drag within reasonable limits.

As the total engine thrust will be greater than the total weight of the aircraft, the question arises of whether wings cannot be dispensed with. If maximum speed is not required to exceed some 250 knots, the fuselage can be wingless and of fairly simple configuration without aerodynamic refinements. A " lift vehicle " of this kind is shown in the accompanying drawing. It would have a powerplant with a lift of some seven tons for an installed weight of one ton. Making full allowance for airframe weight, ejection seats, parachute for landing the whole machine in the event of engine failure, etc., there would still be 4½ tons available for fuel and payload. Such a machine would thus have roughly the same lifting capacity as today's largest helicopters, but would fly at about twice the speed. ◆◆

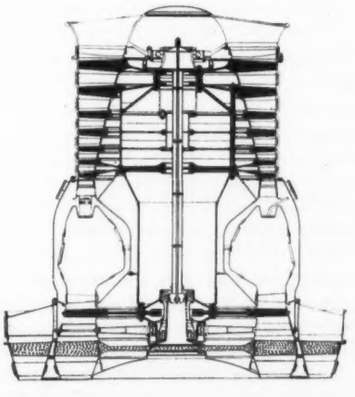


This wingless lift vehicle for medium cruising speeds (according to Dr. S. G. Hooker) would have roughly the same lifting capacity as today's biggest helicopters.

Sectioned drawing of a lift-plus-thrust engine for single-engine (and single-seat) military aircraft. The jet is deflected downwards to give vertical lift, rearwards for forward thrust, or in any inclined position for a combination of lift and thrust.



Lift engine for take-off and landing (Bristol Siddeley Engines project). A thrust/weight ratio of 14 : 1 is foreseen.



Postsputnik Era

Nuclear propulsion in the air is, alas, far from being a reality, at least in the western world. Little is known about progress in Russia although there have from time to time been reports that a nuclear-powered test bed is already in the air. On the other hand, until recently it was impossible to assess the position in the west although it was known that various reactor systems were being developed in the United States, Great Britain and France. The complicated and often frustrating history of the U.S. Aircraft Nuclear Propulsion programme (ANP) only fully came to light when the Subcommittee on Research and Development of the Joint Committee on Atomic Energy met for the first time in public session on July 23rd, 1959.

In reviewing ANP, it is as well to consider what are the true advantages of nuclear powerplant as opposed to chemically-fuelled engines. In fact, are atomic aircraft engines necessary at all? The development of aviation has followed a steady growth of flight speed, range and altitude, but it has not yet been feasible to combine maximum capacity in these three criteria in one single aircraft. To obtain this utopian machine nuclear power is the answer, because it will permit aircraft to maintain high supersonic speeds over theoretically unlimited flight ranges.

Most of the nuclear aircraft engines at present under development are of the turboprop or turbojet type. The reactor derives its heat from the controlled fission of uranium-235 (or other fissionable matter such as thorium or plutonium), one pound of which liberates heat equivalent to the energy released by burning about 1,700,000 lb of petrol.

It is difficult to imagine full development of interplanetary flight without atomic energy sources, although there are many who believe that the first manned flight in space will be made with chemically-fuelled plant. In rocketry, the most obvious advantage of nuclear fuel is the colossal energy or thermal capacity it provides, but as yet the volume of fuel required is unfortunately not necessarily less than for conventional plant. For a rocket to attain high velocity, what is needed is not only energy but also a mass to be expelled backward, thus creating thrust. Energy in sufficient quantities can be generated by fission of nuclear fuel, but application of this energy in the form of heat is of little use since there is not enough mass available to create thrust; therefore a rocket with an atomic liquid-fuel engine, like an ordinary rocket, must carry enormous quantities of its working medium aboard, together with an inertial mass which is able to convert the thermal energy of the nuclear reactor into the kinetic energy of a continuous gas jet.

There are, of course, many other considerations in the future of manned or unmanned nuclear-powered space flight, but this article will concentrate on the more immediate prospects of nuclear power for conventional aircraft within the ANP programme. Since technical progress behind the Curtain is largely a matter of conjecture, at least as far as aircraft nuclear propulsion is concerned, we are unable to compare East and West and can only attempt an assessment of the present situation in the United States.

The first study project within the ANP programme was initiated under contract to the United States Air Force in May 1946 by the Fairchild Engine and Airplane Corporation, with the object of exploring the feasibility of nuclear-powered aircraft. This was the so-called NEPA project (Nuclear Energy for the Propulsion of Aircraft) which was reviewed by various governmental and non-governmental groups during the next several years and particularly by the Massachusetts Institute of Technology, from which emanated the controversial "Lexington Report" in September 1958, predicting the feasibility of nuclear flight in about 15 years.

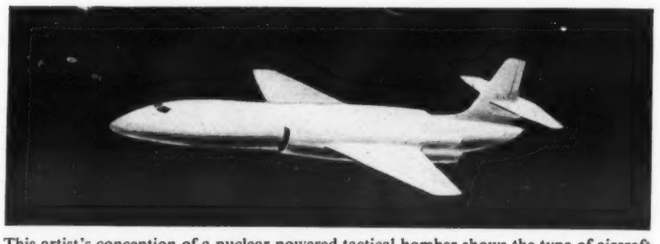
In 1951, the NEPA programme was passed to an industrial contractor, the General Electric Company, for development of a propulsion plant suitable for military aircraft. By 1952 plans were under way to flight test a nuclear propulsion system in the 1956-58 period, using a converted B-36 as a flying test bed. Later in 1952, the Office for Aircraft Nuclear Propulsion (ANPO) was established to coordinate Atomic Energy Commission and Defense Department participation in the programme, in accordance with suggestions originating from the Joint Committee on Atomic Energy.

Since 1953, the whole ANP programme has suffered either from financial difficulties or from a surfeit of administration. At one stage ANP was cancelled completely, and had the Joint Committee not partially saved the situation by energetic intervention, there would be no possibility today of nuclear-powered flight in the West before the mid-1970s.

A serious setback was the cancellation of the plans for a flying test bed. The modified B-36, known as the X-6, was to be used for flight trials of the direct-cycle system proposed by the General Electric Company. This reactor would have been water moderated, and it was proposed to solve many of the problems of development by installing it in the flying test bed. Much of the present-day confusion in the ANP programme may well be imputed to the cancellation of this research for reasons of economy.

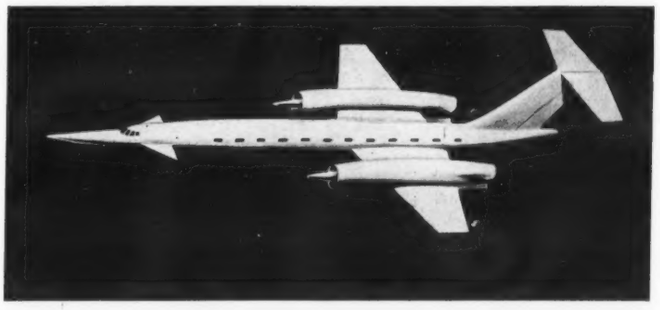
One of the basic principles of ANP policy has been that the objective of the programme should be the development of a militarily useful powerplant and that expenditure on intermediate stages of research should be avoided. This principle still applies, but because no specific financial allocation for airborne research and development has been available, the direct-cycle reactor is not likely to be in the air in the foreseeable future. The most pressing issue in ANP is thus the initiation and timing of a flight-test programme for a nuclear propulsion system; at the same time, it might also be wise to fill another obvious lacuna in the whole history of ANP in the United States: the absence of a definite deadline date for first flight with a prototype test bed.

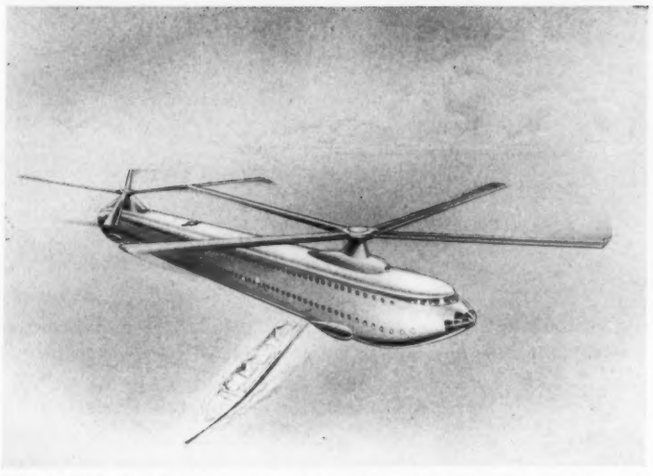
While testifying before the Congressional Subcommittee on Research and Development, Major General Donald Keirn, who was then Director of the ANP project, stated that it would now be appropriate to commence the design and construction of an experimental aircraft suitable for flight testing the various propulsion systems presently under development and for evaluating the characteristics of such an aircraft. Although the pro-



This artist's conception of a nuclear powered tactical bomber shows the type of aircraft that Lockheed Aircraft Corp. foresees as a practical design for the future.

An atomic airliner would travel at Mach 2 or faster and would have infinite range. Many millions of dollars have already been spent on research to establish practicable designs.





This sketch by Bell Helicopter Corp. shows what a drawing-board conception of a nuclear powered VTOL looks like. The helicopter would be about 300 ft long, weigh some 500,000 lbs, and would have a cruising speed of 200 m.p.h. Feasibility studies for this giant have now been completed.

pulsion system used might not necessarily comply with all the criteria for a militarily useful aircraft stipulated by the Department of Defense, General Keirn believes that such a development would serve to perfect the design of powerplant outside the reactor core, the combination of powerplant and airframe as a complete unit, and help to solve the many problems of flight, maintenance and servicing.

General Keirn's opinion would seem to be borne out by experience in nuclear submarine development. The *Nautilus* was a test bed in another element, and only because she was built has it been possible to perfect nuclear submarine systems to the present stage. *Nautilus* was a vast operation both from a financial and technical point of view, but without the huge effort involved subsequent generations of nuclear powered submarines would still be many years away, and the advanced *Polaris* might well have had no *raison d'être*.

Let us now turn to a verbal dromedary, the CAMAL (*C*ontinuously *A*irborne, *M*issile launching *A*nd *L*ow level penetration) system. CAMAL constitutes the militarily useful aircraft sought by the Department of Defense, and it is worth noting that an operational requirement for such a system was only issued in October 1958. The major effort of the ANP project is now devoted to CAMAL, and a design/management competition was held earlier this year between the various industrial companies interested in the potentials of nuclear power in the air.

It now seems likely that two development projects will be initiated on the basis of a design (known as the Model 54) using the direct cycle system submitted by the Convair Division of General Dynamics during this competition.

But whether CAMAL is ever fully realized or not, some form of airborne nuclear propulsion is entirely feasible in the present state of the art, and the only really important questions are, in the words of John A. McCone, does one wish to fly on nuclear power, when, and with what kind of performance? Although the answers depend on a very large number of factors, including finance and available materials, in a world that is being dazzled by Russian prowess in space technology, United States achievement in ANP would do much to balance the scales of prestige—if it is not already too late.

Presumably the main reason that ANP development has been concentrated on military as opposed to civil aircraft is the grave problem of shielding: the production of a material which is light enough to permit flight and yet provides sufficient protection against radiation to both passengers and crew. It is obviously easier to protect two or three crew members than it is to shield a large number of passengers. In view of the weight problem, special materials are essential if a practical nuclear powered plane is to fly, and it is probably in this field that the ANP programme to date has had the biggest success. A considerable proportion of the programme's budget during the past 13 years has been applied to research and ground testing of materials for use in both reactor construction and shielding. Some two or three years ago, it was reported that materials had been developed permitting the weight of the shielding to be drastically reduced and that an atomic aircraft with a flying weight of only 42 tons was already on the drawing-board; but there has been no specific news of more recent developments in this direction. One thing seems to be unavoidable—as long as men fly in nuclear powered aircraft, shielding will be essential. Mass is the only protection against nuclear radiation and thus some lighter solution than the two feet of reinforced concrete found under similar circumstances on land is obviously highly desirable.

Those who have visited conventional nuclear reactors, or other plant such as linear accelerators, will have seen for themselves the amount of civil engineering work required to protect the operating staff and the surrounding population. But nuclear plant on land cannot crash. What happens if a nuclear powered aircraft does?

This subject has been discussed frequently in recent years, and there have been many uninformed and pessimistic comments about this potential danger. The problem has been considered during the ANP programme, and it seems unlikely that much more will be known until nuclear power is in the air. Even at this stage, however, it appears improbable that the danger of radiation following a crash will in any way impair the practical airborne use of reactors and fissionable material. A very comprehensive experimental programme is at present in progress to identify all circumstances and conditions which could result in possible injury to people or damage to property, and when this programme is completed it should be possible to establish operating techniques and procedures that will all but nullify risks of radiation. One form of protection will certainly be very strict discipline in flight, and the same regulations that now apply to civil and military flying, such as corridors and airways, will have to be applied more stringently.

It may at this stage be useful to discuss briefly the type of reactor on which most research is being carried out in the United States and Great Britain. We have already mentioned the direct cycle which provides direct heat to a turbojet engine. As far as can be judged this system is preferred to the indirect cycle which transfers heat through a liquid metal, and a series of tests on a pilot heat transfer reactor was carried out in 1956. The test rig used in this case is air cooled and water moderated, and contains metallic fuel elements. The principle is that air enters the turbojet engine, is compressed, collected in a scroll, and ducted to a manifold on top of the shield tank. The air then passes through a number of parallel ducts and enters the air plenum chamber above the reactor. The air is heated while passing through the reactor and then enters another plenum chamber at the reactor exit. From this point the air returns to the engine, turns the turbine that drives the engine compressor, and is exhausted through the jet nozzle.

This system worked throughout a 140-hour test period, partly on nuclear power only, and one of the conclusive results of the experiment was that "health physics personnel determined that the fission products released during a specific period of 90 hours created no hazard."

However distressing financial considerations of major development may be, money is still the root of all progress. Including the provisions made in the 1960 budget, approximately one billion dollars will have been expended on ANP in the United States alone. Current opinion seems to think that the money has not been wisely spent, and the Congressional Joint Committee on Atomic Energy apparently shares this view. In a statement issued to the press on July 21st, 1959, the Committee said, *inter alia*, that it had tried to be patient in the hope that the Defense Department and the AEC would come to Congress with a firm programme, including a definite schedule for flight testing the direct cycle propulsion system which, in the view of competent technical authority, is ready for proving in actual flight.

Proof of informed public interest is contained in a highly critical letter addressed to President Eisenhower on January 14th, 1959, by Mr. John W. Darley, an industrial manager closely connected with the ANP programme. Mr. Darley has estimated that there are no less than seven governmental, military or official bodies which in one way or another influence the ANP, either from near or from far. If this situation does in fact exist, it can be of little surprise to anyone concerned that the objectives of the programme are still a matter of violent contention. Decentralized administration of such an important national undertaking can only lead to delay, confusion and frustration, but perhaps the public hearing will at least serve to streamline the programme and accelerate the procedure so that the West can pull together in this aspect of the postsputnik era. ◆◆

YS-11

Six Japanese Companies Build an Airliner

Mockup of the YS-11 turboprop transport at Japan Aircraft Manufacturing Company's Sugita plant.

In 1956 the Japanese Ministry of International Trade and Industry decided to promote the development of a medium-haul commercial transport and thus give the country's reborn aircraft industry the backing it so urgently needed. The major aircraft firms set to work enthusiastically on project studies, and when the Government provided a substantial development credit the following year the six largest manufacturers combined forces to launch the project towards practical realization. These six companies were Fuji Heavy Industries Ltd., Japan Aircraft Manufacturing Co. Ltd., Kawasaki Aircraft Co. Ltd., Mitsubishi Heavy-Industries Reorganized Ltd., Shin Meiwa Industry Co. Ltd., and Showa Aircraft Industry Co. Ltd.

In May 1957 these " big six " formed the Transport Aircraft Development Association with the object of coordinating their work and avoiding duplication. Former Mitsubishi Vice-President Paul Taizo Shoda was elected Chairman, and the four-man Senior Council was headed by Dr. Hidemasa Kimura, professor of aeronautical engineering at the Nihon University, Tokyo. The Council assumed responsibility for planning, structure, aerodynamics and equipment for the projected aircraft, backed by a Technical Committee and an Operations Research Committee. Planning was in the hands of Minoru Ohta, a Director of Fuji Heavy Industries Ltd. and chief designer at Nakajima during World War II; he designed the Hayate *(Frank)* naval fighter, for example. The structures section of TADA was headed by Jiro Horikoshi, of Mitsubishi Heavy Industries, creator of the wartime *Zero-Sen* fighter. Head of the aerodynamics section was Shizuo Kikuhara, of Shin Meiwa, former design chief of Kawanishi Aircraft Co. and designer of the *Emily* flying boat (Type 2). The fourth member of the Council and head of the equipment section was Takeo Doi (Kawasaki), who designed the Hien *(Tony)* Army fighter during World War II. The provisional goals of the association—preparation of specifications, design work, wind tunnel tests and construction of a full-size mockup—were reached in December 1958 with the completion of the mockup at Japan Aircraft Manufacturing Company's Sugita plant.

Then, early in 1959, an amendment to the Aircraft Industries Promotion Law turned the Transport Aircraft Development Association into a trading company, known as Nihon Aeroplane Manufacturing Co. Ltd., with capital provided by the Government and the private companies concerned. The Board of Directors of the new company is composed of representatives of the Government and of the " big three "—Fuji, Kawasaki and Mitsubishi; and Taizo Shoda is Chairman. Authorized capital was 2,000 million yen (approx. $5,550,000), of which 500 million yen have so far been paid up (300 million by the Japanese Government and 200 million by the private companies). However, the capital is to be raised each year to reach a final total of 4,200 million yen in 1963. With this money NAMC plans to build two prototypes, which are scheduled to begin flight testing towards the end of the 1961 fiscal year. It is also planned to supply two more prototypes for static load and fatigue tests and at the same time to begin quantity production of the YS-11, so that the first aircraft can go into operation on the Japanese domestic routes in the second half of 1963.

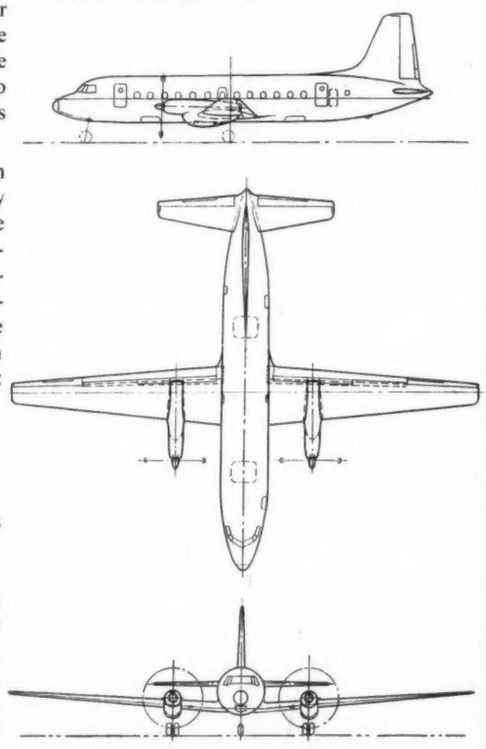
The project was thoroughly examined from all sides in more than two years of study before the present configuration and size were selected. The outcome is a twin-engine low-wing design for short-haul operations, powered by two Rolls-Royce *Dart RDa.10* propeller turbines and laid out to accommodate 50 to 60 passengers. The YS-11 has been designed to meet the following requirements:

1. Highest profitability on short routes
2. Good take-off and landing qualities
3. Fatigue-proof and fail-safe structure
4. Optimum equipment for local services
5. De luxe passenger cabin if required.

When the first mockup was completed in December 1958, the fuselage was subjected to a re-examination, as a result of which certain modifications were made as regards window size, cockpit arrangement, canopy design, disposition of toilets, etc. These modifications were incorporated in a second mockup, which was completed in October 1959. During the current fiscal year, Nihon Aeroplane Manufacturing Company will prepare the works drawings, begin static load tests on parts and small assemblies and acquire the necessary jigs and tools.

As NAMC has no manufacturing facilities of its own, production of the YS-11 will be divided mainly between the " big three. " Mitsubishi will be responsible for manufacture of the fuselage and certain equipment items, as well as for final assembly; Kawasaki will provide the wings; and Fuji the tail unit. Then there will also be countless subcontractors. Overall responsibility, however, will rest with NAMC, who will also handle all export discussions and talks with the Japanese Defense Agency regarding the possible purchase of a modified version of

Three-view drawing of the YS-11.



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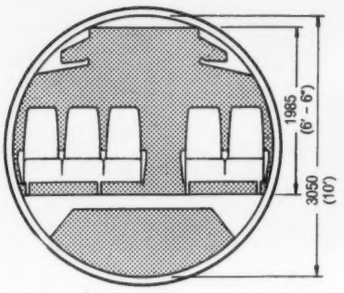
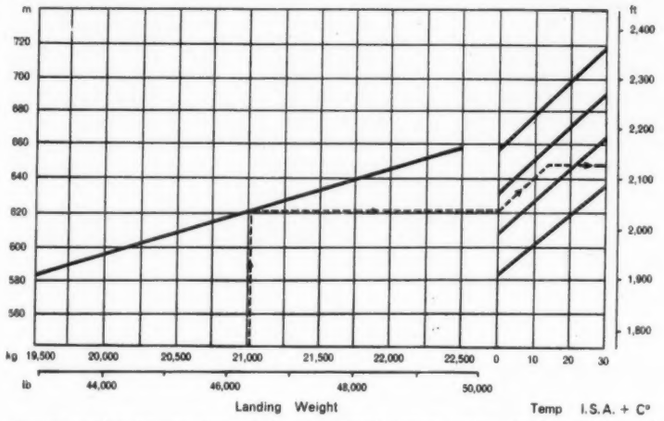
the transport for the Japanese Self Defense Forces.

Obviously it is not yet possible to forecast what the production run will be, but NAMC expects to be able to sell some 150 YS-11s during the seven years between 1963 and 1970—at a unit price of roughly 350 million yen ($970,000). All Nippon Airways definitely plans to use the YS-11 on its domestic routes, and if the Japanese industry succeeds in securing a foothold in South East Asia and possibly also in South America the future of this DC-3/DC-4 successor should be assured.

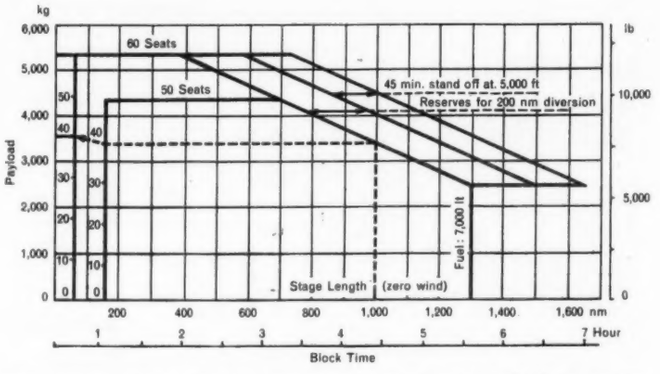


Cross section of the fuselage for the version with five abreast seating. Seat width is 16.9 in., width of aisle 15.8 in.

Seating layout for 55 passengers. In this version the number of windows has been increased compared with the 60-seat model (see mockup); the two toilets were originally located in the rear, but have since been moved to the forward portion of the fuselage.



Design landing distance (from 50 ft. at sea level) plotted against landing weight and ground temperature (ISA + °C).



Payload/range diagram for ISA conditions, take-off weight 49,500 lb, cruising altitude 20,000 ft and cruising r.p.m. of 14,000. Payload is plotted against stage length, and the diagram also gives block time.

Technical data for the YS-11

Powerplant:

Two Rolls-Royce *Dart RDa.10s* of 2,660 e.h.p. each take-off power at 15,000 r.p.m.
These engines can be equipped with a water/methanol injection system to increase take-off power or maintain rated power under all temperature and pressure conditions.

Propeller diameter	14 ft 6 in.

Dimensions:

Span	105 ft
Length, overall	84 ft 8 in.
Fuselage width	10 ft 8 in.
Wing area	1,022 sq. ft.
Aspect ratio	10.8
Thickness/chord ratio	18-12%

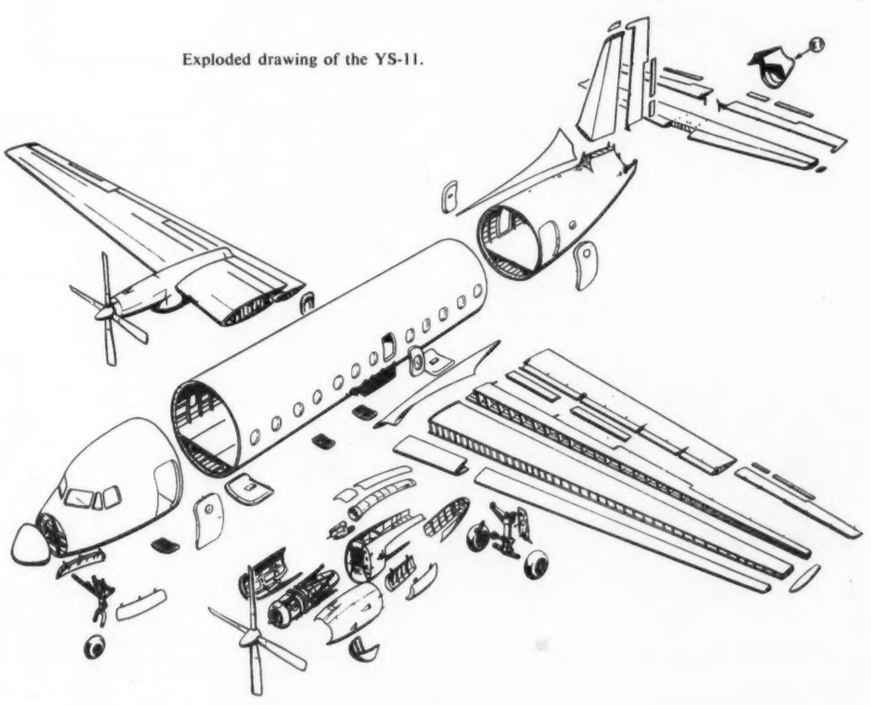
Weights:

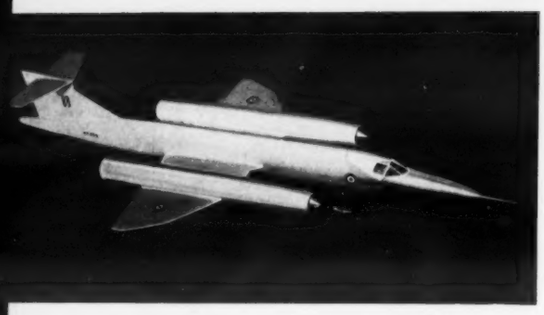
Airframe	15,865 lb
Powerplant	5,865 lb
Equipment	8,090 lb
Weight equipped	29,820 lb
Crew, baggage, etc.	1,200 lb
Operating weight empty	31,020 lb
Passengers	10,890 lb
Fuel	7,590 lb
Gross weight	49,500 lb

Loading and performance:

Wing loading	48.34 lb/sq.ft.
Power loading	9.3 lb/h.p.
Cruising speed/height	265 kts/20,000 ft
Range/payload	540 n.m. with 60 passengers
ICAO runway length	4,000 ft.

Exploded drawing of the YS-11.





The Bristol T.188 Research Aircraft

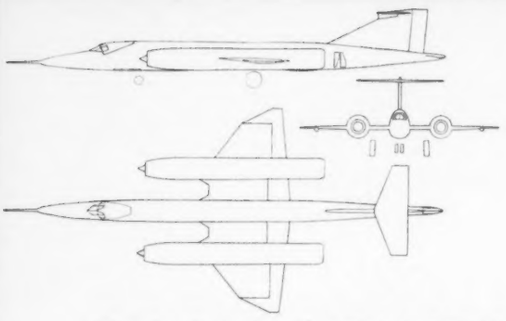
A single-seat twin-jet research aircraft, designed specifically for aerodynamic and structural tests at high supersonic speeds (Mach 2.5 to 3), is now nearing completion at Bristol Aircraft's Filton plant, for the Ministry of Aviation. The original specifications for the Bristol T.188 also called for the aircraft to be used as a test vehicle for new types of weapons and propulsion systems. However, changes in defence policy led to a modification of these requirements, and the aircraft now being built will be used only for flight tests within the above-mentioned speed range. For this purpose it will carry a heavy load of instruments and recording equipment.

To cope with the problem of kinetic heating at high supersonic speeds, the airframe is constructed of stainless steel, with ceramic coating at certain points. Power is supplied by two de Havilland *Gyron Junior DGJ.10s* each delivering a max. static thrust of 14,000 lb with reheat. The installation of two jets in separate nacelles in the wing has the advantage that the engines can be changed without major modifications to the airframe. The manufacturers also point out that this arrangement makes for favourable shock wave interactions between fuselage and nacelles, which substantially reduce drag. Nose wheel and main undercarriage units are retracted into the fuselage, which also accommodates all fuel tanks and the major equipment items.

The wing planform was selected to give low wave drag at supersonic speeds, while maintaining good characteristics in the transonic range. To escape the jet efflux of the engines, the all-flying tailplane is fitted on the top of the swept-back fin, but in front of the rudder. The fuselage is of oval section, slightly "waisted" in the centre portion to meet the requirements of the area rule. An interesting feature is the planform of the ailerons, which extend outboard from the engine nacelles to the wing tips where they advance right to the leading edge.

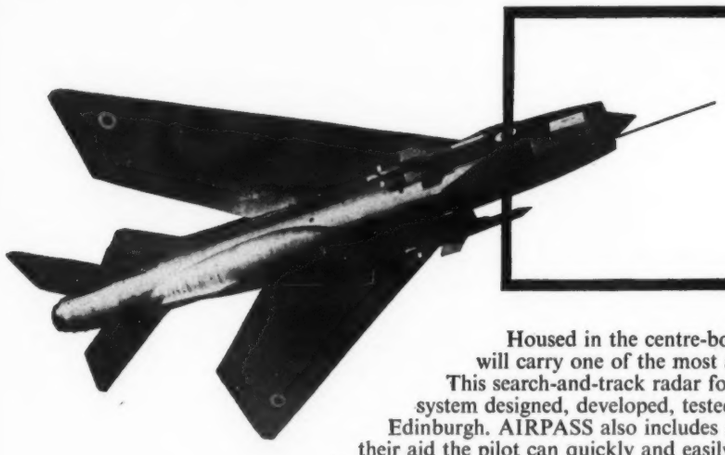
The T.188 research programme will undoubtedly furnish valuable information on the qualities of new materials, new systems and new equipment. But it has already done more. Its manufacture has necessitated the solution of a number of fabricating problems, such as the machining and welding of steel plates, which were entirely new to the British aircraft industry.

Flight testing is due to begin early this year. The first phase will be devoted to proving the aircraft's basic flying qualities and handling characteristics. Then flight speeds will be increased progressively to transonic and, ultimately, supersonic levels. ↔



Basic date for the Bristol T.188

Overall length	71 ft	Sweepback outboard of nacelles	38°
Fuselage depth	4 ft 11.5 in.		
Fuselage width	3 ft 9 in.	Sweepback of wing tips	64°
Span	35 ft 1 in.		
Wing area	396 sq. ft.	Sweepback of fin	65°
Thickness/chord ratio (modified biconvex section)	4%		



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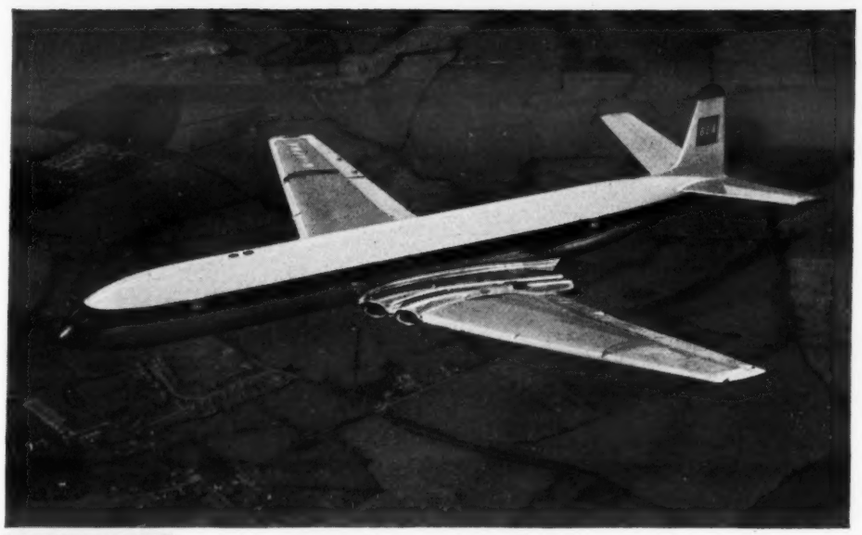

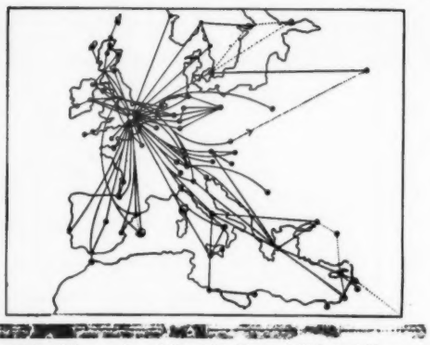

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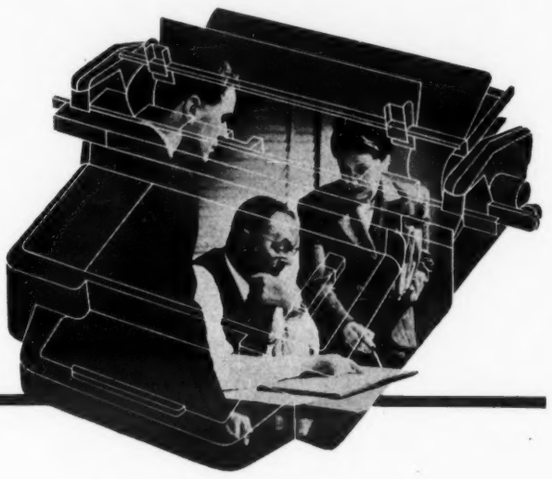

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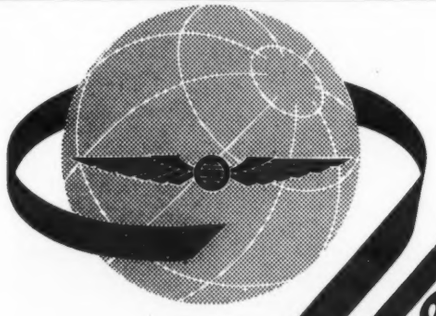

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